TM 11-5825-205-35

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

FIELD AND DEPOT MAINTENANCE

RADIO TRANSMITTING SET AN/FRN-22A

HEADQUARTERS, DEPARTMENT OF THE ARMY

MARCH 1960

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 500- or 250-volt plate and power supply circuits, the −100-volt bias supply circuits, and on either the 230- or the −115-volt ac circuits.

DON'T TAKE CHANCES

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Power Supply PP–1329/FRN–20	1,350-volt circuits
Audio Frequency Amplifier AM–1246/FRN–20	1,350-volt circuits
Electrical Equipment Cabinet CY–1899/FRN–22	1,350-volt circuits
Electrical Equipment Cabinet CY–2274/FRN–22A	1,350-volt circuits

RADIOACTIVE TUBES

Before handling or disposing of defective Voltage Regulator tubes OA2WA and OA2WB, refer to TB SIG 225, Radioactive Electron Tube Handling.

TECHNICAL MANUAL
No. 11–5825–205–35

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C., *2 March 1960*

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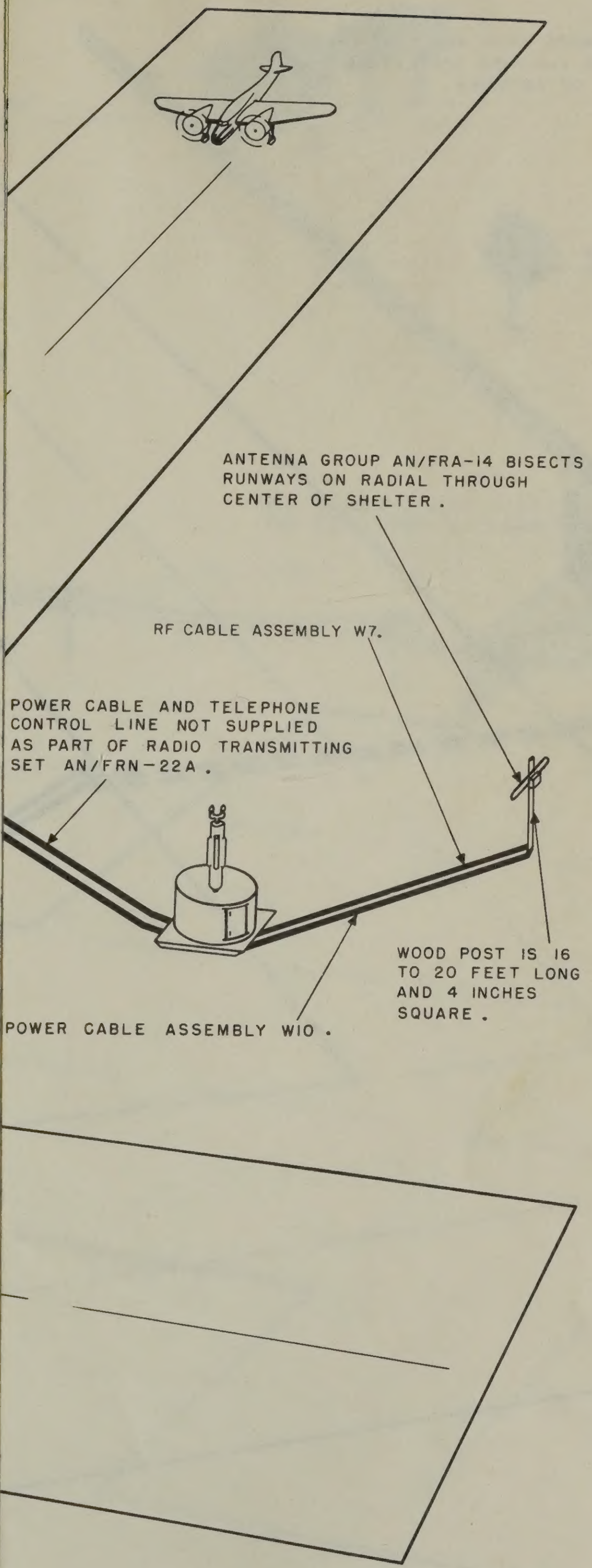
ANTENNA GROUP AN/FRA-14 BISECTS RUNWAYS ON RADIAL THROUGH CENTER OF SHELTER.
RF CABLE ASSEMBLY W7.
POWER CABLE AND TELEPHONE CONTROL LINE NOT SUPPLIED AS PART OF RADIO TRANSMITTING SET AN/FRN-22A.
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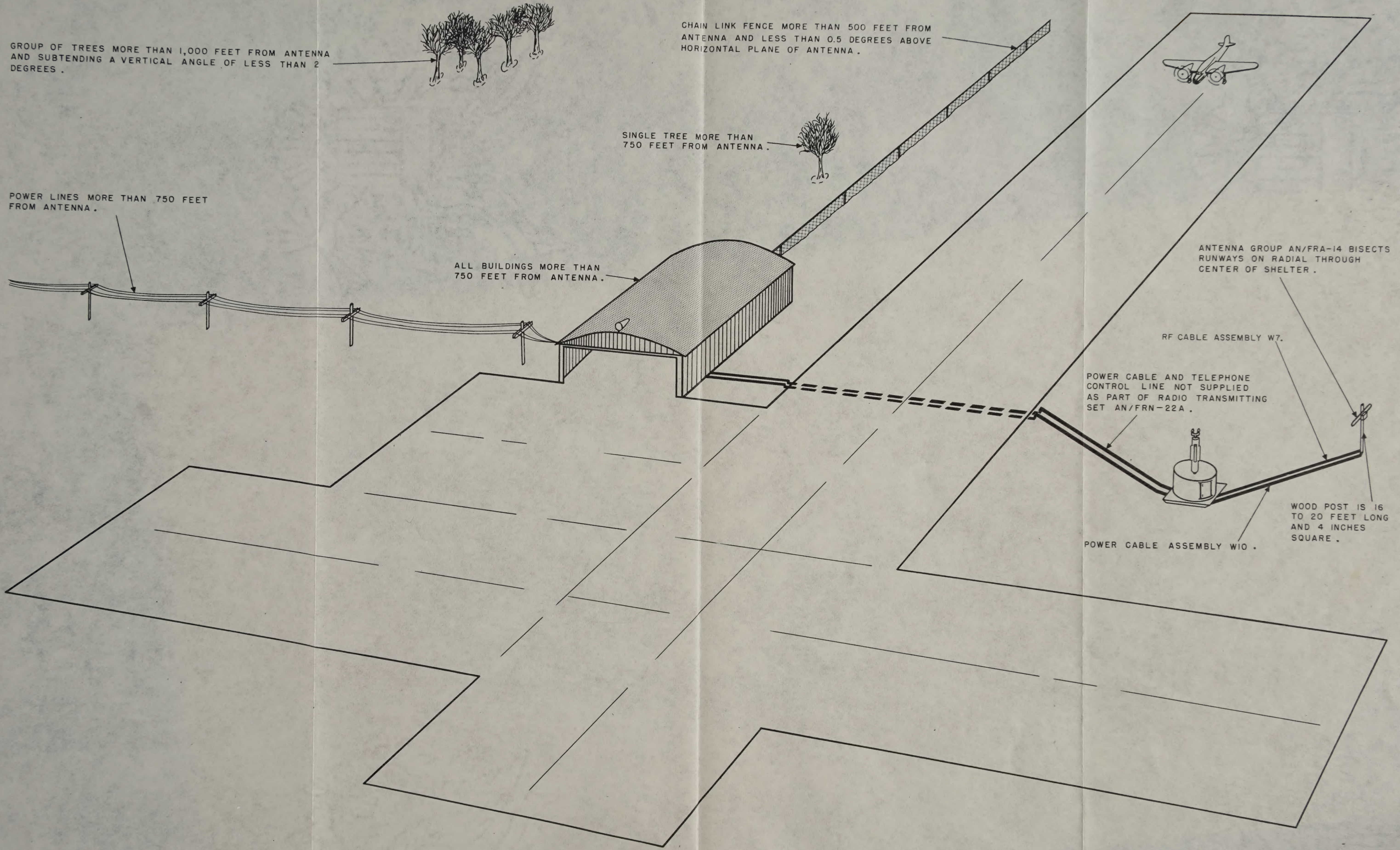
GROUP OF TREES MORE THAN 1,000 FEET FROM ANTENNA AND SUBTENDING A VERTICAL ANGLE OF LESS THAN 2 DEGREES .
CHAIN LINK FENCE MORE THAN 500 FEET FROM ANTENNA AND LESS THAN 0.5 DEGREES ABOVE HORIZONTAL PLANE OF ANTENNA .
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Figure 1. Radio Transmitting Set AN/FRN-22A, typical site.

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CHAPTER 1

INSTALLATION

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

1. Scope

a. This manual covers installation and field and depot maintenance for Radio Transmitting Set AN/FRN–22A. It includes instructions appropriate to third, fourth, and fifth echelons for troubleshooting, testing, and repairing specified maintenance parts. It also lists tools, materials, and test equipment for third, fourth, and fifth echelon maintenance. Detailed functions of the equipment are covered in the theory section.

b. In chapter 2, which covers the theory, the component parts on the partial schematic diagrams have reference designations that indicate in which major component a part appears. For example, a part designated "N/T1001" is located on the antenna pedestal. A list showing the reference designations and the components appears in appendix I.

c. The complete technical manual for this equipment includes one other publication; TM 11–5825–205–12.

d. Forward comments concerning this manual to Commanding Officer, U.S. Army Signal Publications Agency, Fort Monmouth, N.J.

Note. For applicable forms and records, see paragraph 2, TM 11–5825–205–12.

e. For the convenience of installation and maintenance personnel, a cross-reference list of common-name assignments is given in the following table.

Common name	Nomenclature
Antenna	Antenna AT–669/FRN–22.
Goniometer	Electrical Goniometer GO–12/FRN–20.
Keyer	Keyer KY–175/FRN.
Meter panel	Indicator Panel SB–830/FRN–22A.
Modulation eliminator	Modulation Eliminator MX–1843/FRN–20.
Monitor	Course Monitor MX–1837/FRN–20.
Obstruction light	Aircraft Obstruction Marker Light MX–1919/FRN–22.
Omnirange set	Radio Transmitting Set AN/FRN–22A.
Remote control cabinet	Electrical Equipment Cabinet CY–1826/FRN–20.
Remote control unit	Radio Set Control C–1739/FRN–20.
Shelter	Electrical Equipment Shelter S–120/FRT–22.
Shelter blower	Propeller Ventilating Fan HD–244/FRN–22.
Skid	Platform Skid MX–1918/FRN–22.
Transmitter	Radio Transmitter T–573/FRN–20.
Voltage regulator	Voltage Regulator CN–358/FRN–22.

2. Siting

The quality of the navigational signal radiated from a very high frequency omnidirectional range (vor) station depends on the obstructions and terrain in the immediate vicinity of the antenna as well as the obstructions and terrain within the service range of the station. An ideal site would be located on the highest ground in the vicinity to provide maximum coverage, with level terrain cleared of all objects for a radius of at least 3,000 feet, and no obstructions extending above the horizontal plane of the antenna within the service range of the station. In most localities, it is not possible to meet the ideal site requirements completely, but every effort should be made to obtain the best site available. In many cases, a reasonable amount of grading and obstruction removal will produce a site which will meet all practical requirements. An example of a practical site is shown in figure 1. Although no absolute minimum requirements can be stated, normally, a site will be considered acceptable if it meets the following practical requirements:

a. The terrain adjacent to the antenna should not slope upward from the ground level at the antenna and should be level for a radius of at least 200 feet. Beyond 200 feet, a downward slope may be tolerated if the contours are generally circular about the antenna as a center, and the grade does not exceed 4 feet in 100 feet out to at least 1,000 feet. A combination of flat and sloping ground is satisfactory if a minimum level area with a radius of 200 feet is obtained.

b. The surface of the terrain adjacent to the antenna should be cleared and reasonably smooth, with no irregularities such as ravines, ditches, rock outcroppings, or embankments which are above or below the average ground line by an amount exceeding 1 percent of the distance from the antenna.

c. Although the quality of vor courses is largely determined by the terrain within the area about the antenna, prominent terrain features at greater distances may cause disturbances of considerable magnitude. Distant terrain features which have large, smooth, reflecting surfaces, such as a bluff or mountainside, will cause more disturbance than irregular surfaces.

d. Ordinary farm-type wire fences above 4 feet high should not be permitted within 200 feet of the antenna. Chain-link type fences 6 feet or more in height should not be permitted within 500 feet of the antenna. Beyond these distances, no wire fence should extend more than 0.5° above the horizontal, measured from the antenna. These requirements may be relaxed for fences which are essentially radial to the antenna.

e. A single-pair telephone control line and a powerline are necessary for the operation of the omnirange set. Overhead power and control line extensions should not be run closer than 750 feet to the antenna. The power and control lines between the terminal pole and the shelter must be run along the surface of the ground or buried. Overhead power and control line extensions between 750 and 1,200 feet from the antenna are permitted, if the poles are installed on a radial from the center of the antenna.

f. Single trees, up to 35 feet high, may be tolerated beyond 750 feet from the antenna. Groups of trees should not be permitted within 1,000 feet. From 1,000 to 2,000 feet, it is desirable that all trees subtend a vertical angle of 2° or less.

g. No structures should be permitted within 750 feet of the antenna. All structures which are partly or entirely metallic should subtend vertical angles of 1.2° or less measured from the antenna. Wooden structures with negligible metallic content and with little prospect of future metallic additions (such as roofs and wiring) may be tolerated if subtending vertical angles of less than 2.5°. On airports, structures such as a single hangar or line of hangars and administration buildings can produce interference in the same manner as power and telephone lines. The requirements discussed in *e* above will apply.

h. When the omnirange set is installed on an airport, the shelter should be located, if possible, in an area adjacent to the intersection of the principal runways to provide approach guidance to the ends of the runways. To prevent the shelter from being an obstruction to aircraft, it should be located not closer than 400 feet to the centerline of any runway or 200 feet to the centerline of a taxiway. When located off an airport, select a site so that one of the course radials will provide letdown procedure to one of the runways, preferably the instrument runway.

3. Unpacking

When packed for shipment, the components of the omnirange set are packed in a total of 26 wooden boxes and crates. The smaller components are placed in cartons before being packed in wooden boxes. Three shipping containers, typical of the different types used in packing the omnirange set, are shown in figure 2. Appendix II contains a table of packaging data, including the contents of each box. Remove the contents from the packing boxes and crates in the order outlined below. Open only the boxes necessary at the time to perform the installation. Paragraph 5 gives the correct order for performing installation operations.

Caution: **Be especially careful not to expose electronic components of the omnirange set to the weather. Complete installation of the omnirange set normally requires several days. When there is no weatherproof structure convenient to the installation site in which unpacking operations can be performed, unpack only those components which are to be used immediately. Carefully read the installation**

instructions (par. 5–29) to determine when certain items are required.

a. Box 22/26.

(1) Cut and remove the five metal straps from around the two end caps and three packing blocks.

(2) Use a nailpuller to remove nails from top, bottom, and sides of both wooden end caps. Remove and discard the end caps.

(3) Use a nailpuller to remove nails from the three packing blocks so that the top piece can be removed.

(4) Remove the wood building materials. Discard the packing blocks.

b. Box 21/26.

(1) Position the box so that the 2-foot square plywood section is on top.

(2) Cut and fold back the metal straps.

(3) Use a nailpuller to remove nails from the diagonal brace. Remove the brace.

(4) Pull the nails from the two corner braces. Remove the braces.

(5) Pull the nails from the braces which were banded with the metal straps ((2) above). Remove the braces.

(6) Pull the nails from the wood strips which hold the contents of the box in place. Remove the wood strips.

(7) Remove the 2-foot square plywood section.

(8) Lift out the fiberboard panel.

(9) Remove the plywood section and the two roof sections.

c. Box 23/26.

(1) Pry off the metal straps from the four top corners of the crate.

(2) Use a nailpuller to remove the nails from only the side and end braces which fasten the top of the crate. Remove the top.

(3) Cut and remove the metal straps which hold the wall sections.

(4) Remove the two bolts at each end of the top wall section that fasten the wall section to the ends of the crate. Lift out the top wall section. Remove the five remaining wall sections.

(5) Cut and fold back the metal straps which fasten the two wooden boxes to the center of the crate base.

(6) Use a nailpuller to remove the nails from the tops of both wooden boxes. Remove the contents of these boxes only as required.

(7) Cut and fold back the metal straps which fasten the six channel strips and ground rod to the crate base. Remove the channel strips and ground rod.

(8) Cut and fold back the metal straps which fasten the 12 roof stiffeners to the crate base. Remove the roof stiffeners.

d. Box 24/26.

(1) Set the box so that it rests on its skids.

(2) Cut and remove the metal straps.

(3) Use a nailpuller to remove the nails from top of the box. Remove the top.

(4) Pull the nails which fasten the wooden blocking collar (located at the top of the antenna pedestal) to the sides of the box.

(5) Remove the bolts which fasten the antenna pedestal base to the end of the box.

(6) Stand the box upright and set it on the end at which the antenna pedestal base is located. Remove the pedestal from the box.

(7) Remove the bolts which fasten the wooden blocking collar to the top of the antenna pedestal. Remove the blocking collar.

e. Box 9/26.

(1) Set the box so that it rests on its skids.

(2) Cut and remove the metal straps.

(3) Use a nailpuller to remove the nails from the top of the box. Remove the top.

(4) Pull the nails which fasten the wooden blocking pieces to the sides of the box. Remove the blocking pieces.

(5) Remove the small cartons from the box.

(6) Remove the tape which holds the folded dipole to the upper side of the antenna.

(7) Remove the antenna from the box.

(8) Remove the paper cellulose wadding from the light fixture at the top of the antenna. Remove the tape from the cables wrapped around the end of the antenna support pipe. Remove the paper cellulose wadding from the plugs on the ends of the cables.

(9) Open the two smaller cartons ((5) above). Remove the contents of the cartons.

(10) Put the two larger cartons aside until

box 6/26 is opened. Remove the contents of these cartons in the same way the contents of cartons in box 6/26 are removed.

f. Boxes 1/26 through 4/26 and 20/26.

(1) Set each box so that it rests on its skids.
(2) Cut and remove the metal straps.
(3) Use a nailpuller to remove the nails along the bottom edges of the side of the box. Leave the top, sides, and ends of the box assembled. Lift this top assembly straight up until it clears the component, and set it aside.
(4) Open the moisture-vaporproof barrier along the sealed edges at the end and sides.
(5) Remove the tape from the corrugated paper wrapping. Open the corrugated paper wrapping.
(6) Cut and remove the metal straps that hold the cabinet in place.
(7) Remove the paper pads and lift out the component.
(8) In boxes 1 through 4, remove paper cellulose wadding from around the plugs on the interior of the cabinet.
(9) In boxes 1 through 4, collect all cloth bags, paper envelopes, and packages tied or taped inside the cabinet and place them on the floor of the cabinet.
(10) In boxes 1 through 4, untie the trim strips from the wiring harness strip inside the cabinet. Remove the paper wrapping from the trim strips and stand the trim strips inside the cabinet.

g. Boxes 6/26 through 8/26, 11/26 through 13/26, and 18/26 and 19/26.

(1) Set each box so that it rests on its skids.
(2) Cut and fold back the metal straps.
(3) Use a nailpuller to remove the nails from the top of the box. Lift the toppieces off.
(4) Remove the corrugated cartons from the box. Open the corrugated cartons and lift out the inner cartons inclosed in the moisture-vaporproof barriers.
(5) Open the sealed end of the moisture-vaporproof barrier on each carton. Stand the inner carton on the end on which the seal was just opened. Pull the moisture-vaporproof barrier up and off the carton.
(6) Open each inner carton.
(7) Remove each component and all individually wrapped tubes. Unwrap the components and tubes. Be sure to keep the tubes for each component separate so that, at the proper time, they can be installed in the component with which they were packed.

h. Boxes 14/26 through 17/26.

(1) Set each box on its top with the skids up.
(2) Use a nailpuller to remove the nails around the four edges of the bottom of the box.
(3) Set the box so that it rests on its skids.
(4) Cut and remove the metal straps.
(5) Lift the top assembly, which consists of the top, sides, and ends of the box, straight up until it clears the component, and set it aside.
(6) Open the moisture-vaporproof barrier along the sealed edges at the end and both sides.
(7) Remove the tape from the corrugated paper wrapping. Open the corrugated paper wrapping.
(8) Cut and remove the metal straps that hold the component in place.
(9) Remove the tape, paper pads, and blocking materials.
(10) Remove the individually wrapped tubes. Unwrap the tubes and keep them in a safe place, separate from the tubes for the other components, until it is time to install them.
(11) Lift out the component.

i. Box 10/26.

(1) Complete the procedure given in *h*(1) through (7) above.
(2) Remove the nuts from the bolts that hold the component to the bottom of the box. Lift out the component.
(3) Viewed from the rear of the component, a small chassis with two tubes is mounted to the upper left-hand corner of the front panel. Remove the cardboard packing material from around this chassis.
(4) A cloth bag or paper envelope containing a bolt, nut, and washer is attached to the component. Use these hardware items to fasten the left-rear corner of

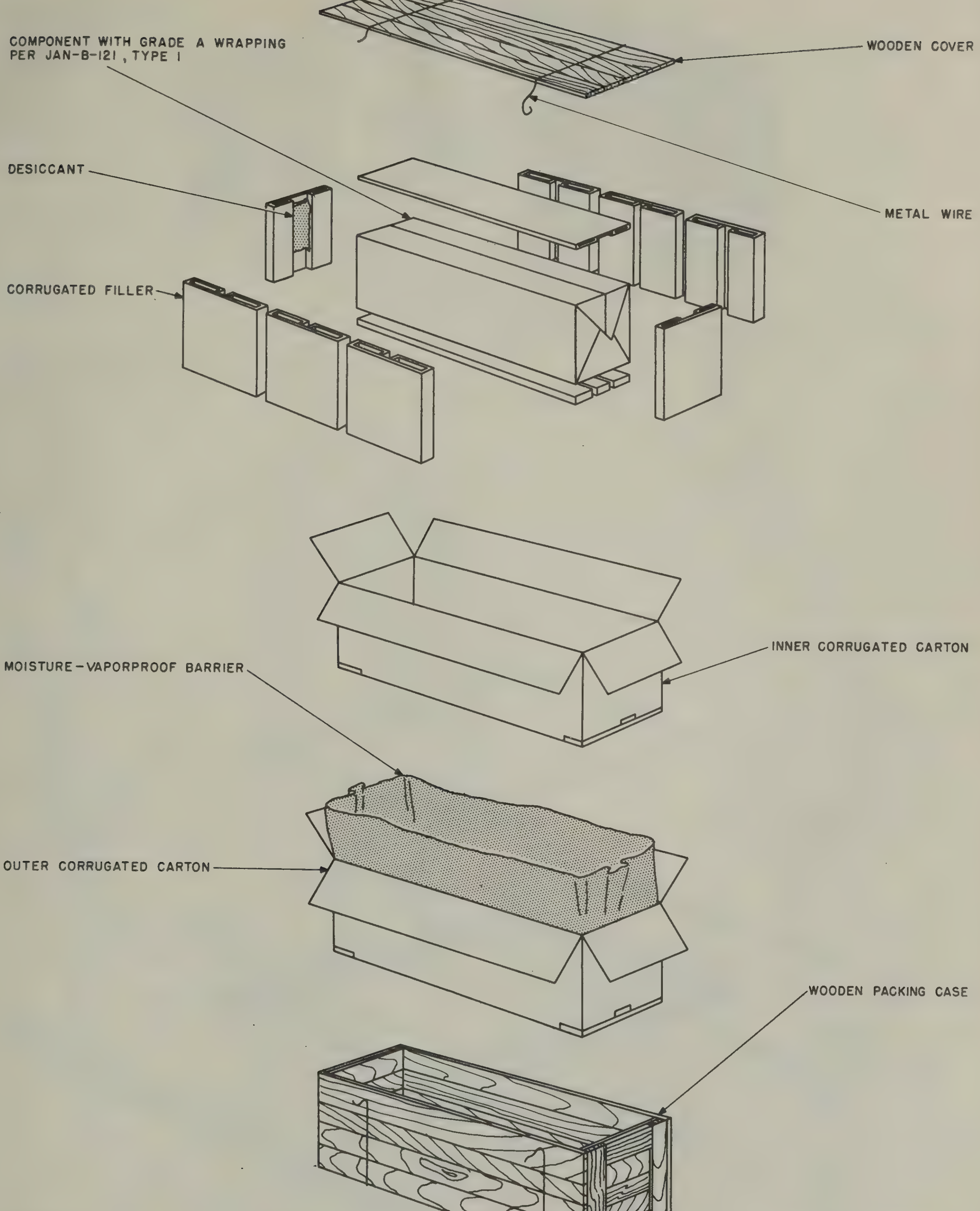


Figure 2. Typical packaging.

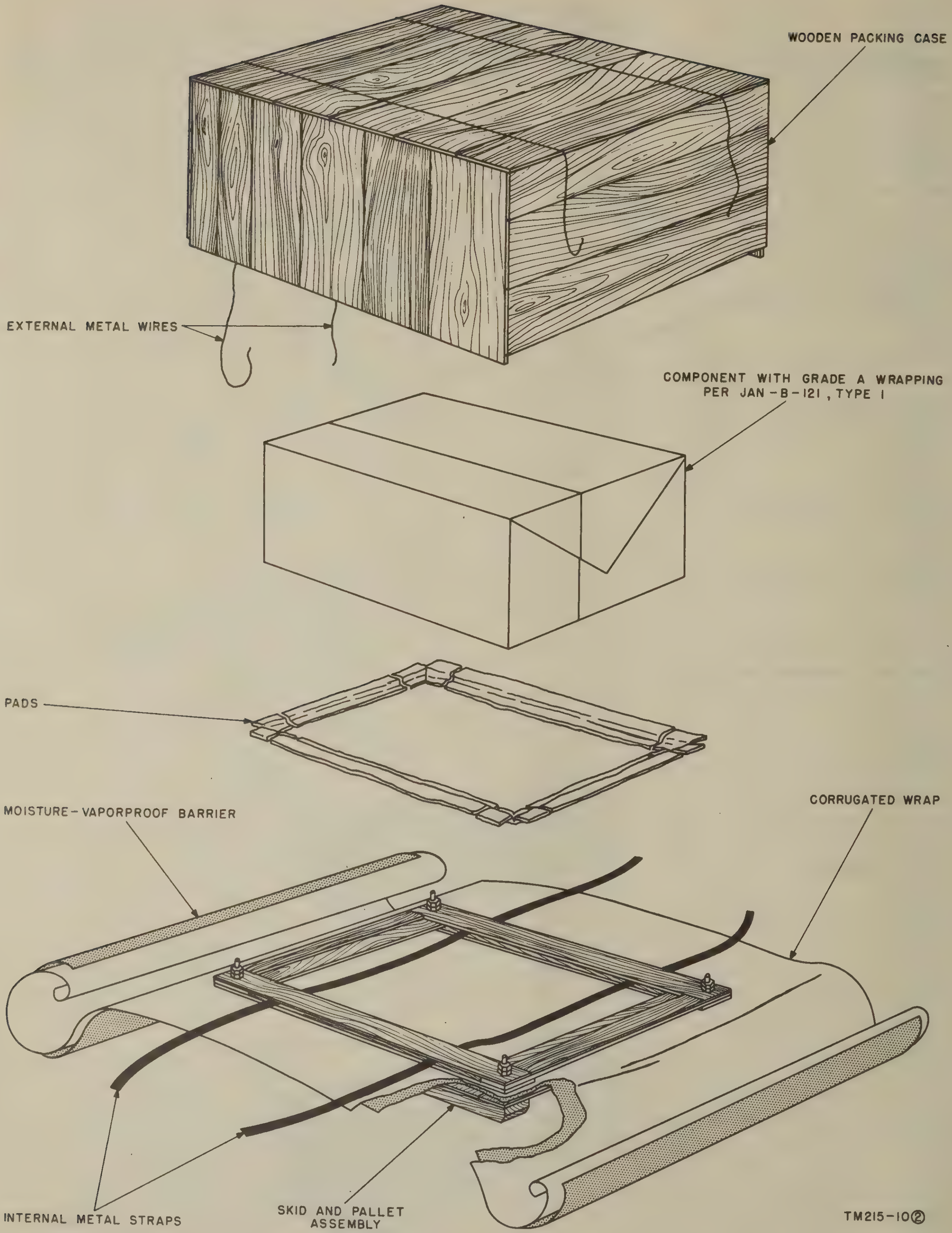


Figure 2—Continued.

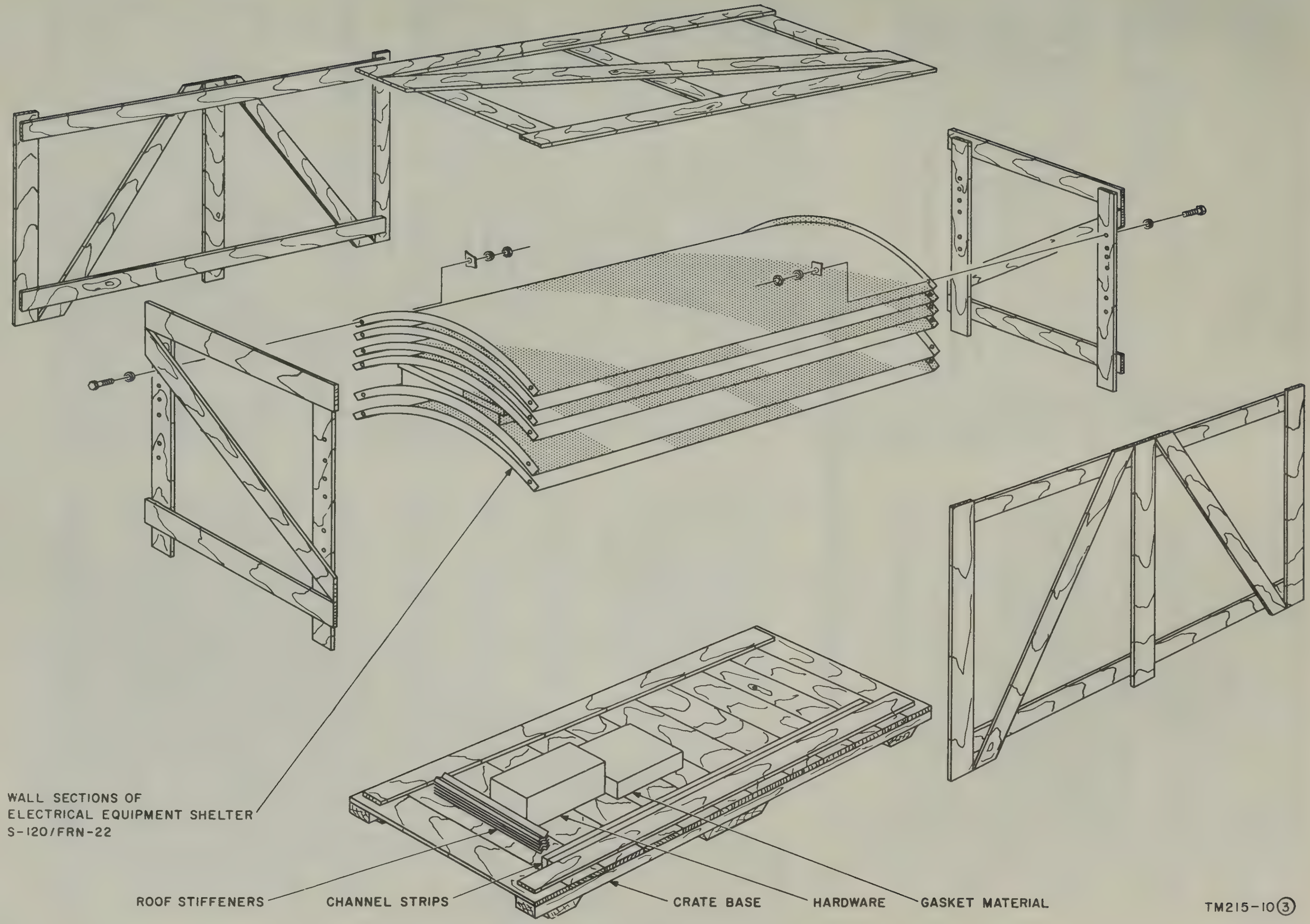


Figure 2—Continued.

the large transformer to the component chassis.

j. Box 25/26.
  (1) Complete the procedure given in *g*(1) through (6) above.
  (2) Remove the contents of the carton.

k. Box 5/26.
  (1) Complete the procedure given in *g*(1) through (6) above.
  (2) Remove and unwrap the component.
  (3) Remove the small cartons and packages from the inside of the cabinet. Unwrap the small cartons and packages.

l. Box 26/26.
  (1) Complete the procedure given in *g*(1) through (6) above.
  (2) Remove and unwrap the contents of the carton.

4. Checking Unpacked Equipment

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, refer to paragraph 2, TM 11-5825-205-12.

b. See that the equipment is complete as listed in the packing slip. If a packing slip is not available, check the equipment against the packaging data in appendix II.

c. If the equipment has been used or reconditioned, see whether it has been changed by a modification work order (MWO). If modified, the MWO number will appear on the front panel near the nomenclature plate. Check to see that this MWO number also appears on the schematic diagram of the manual accompanying the equipment. If not, add a note to the overall schematic diagram.

Section II. INSTALLATION PROCEDURES

5. General

a. Although a minimum of two men can install Radio Transmitting Set AN/FRN-22A, a crew of four men is probably the most efficient under normal conditions. An experienced crew can install the omnirange set in approximately 5 days.

b. Select the equipment location as outlined in paragraph 2. Refer to the unpacking instructions in paragraph 3.

c. Install the omnirange set in the order given below. These steps are outlined in detail in paragraphs 6 through 29.

  (1) Assembly of Platform Skid MX-1918/FRN-22 (box 22/26).
  (2) Preparation and installation of Platform Skid MX-1918/FRN-22 (box 21/26).
  (3) Installation of ground rod (23/26).
  (4) Assembly of Electrical Equipment Shelter S-120/FRN-22 (box 23/26).
  (5) Installation of Propeller Ventilating Fan HD-244/FRN-22 (box 20/26).
  (6) Installation of Antenna AT-669/FRN-22 (boxes 9/26 and 24/26).
  (7) Location and installation of Antenna Group AN/FRA-14 (box 9/26).
  (8) Installation of equipment in shelter (boxes 1/26 through 8/26 and 11/26 through 19/26).
  (9) Installation of branched wiring harness W19 (box 25/26).
  (10) Installation of flexible power conduits.
  (11) Installation of equipment at remote control point (box 5/26).
  (12) Entry of lines and cables into shelter.
  (13) Cabling and connections.

Note. Certain cables must be connected during the installation procedure.

  (14) Installation of tubes and thermal relays.
  (15) Installation of crystals and fuses.
  (16) Installation of cabinet blowers.

d. Except that needed for the skid, all hardware required to assemble or install the components of the omnirange set is attached to components with which the hardware is used. Hardware used to assemble the skid is packed with the shelter hardware.

6. Assembly of Platform Skid MX-1918/FRN-22

(fig. 3)

When possible, assemble the skid on the site for the omnirange set. However, this work can be done in a hanger or building reasonably near the site and the skid either towed into position or moved on a flat-bed truck. Parts from which the skid is to be assembled are supplied with the omnirange set and are listed on the skid assembly drawing. The skid assembly procedure (*a-c* below) refers to the parts by the item numbers shown on figure 3. Refer to the figure as each step in the assembly procedure is performed.

a. Assembly of Skid Frame and Runners.

(1) Use two sideplates (1) and two joists (2) to make the frame of the skid. Lay out these four pieces to form a square, with the joists between the sideplates. Be sure that the sideplates are positioned so that the beveled corners are at the bottom.

(2) Two men are required to mark the holes to be drilled for the brackets (3). One man holds the ends of one sideplate and one joist together to form a corner. The second man fits a bracket into the corner ¼ inch down from the top edges, holds it firmly in place with one hand, and uses the bracket as a template to mark the location of the holes. Repeat this procedure at each of the four corners.

(3) Drill a ½-inch diameter hole at each location marked in *b* above.

(4) Use 6 bolts (4), 12 washers (5), and 6 nuts (6) to fasten each corner bracket (3) in place. Put one washer on each of the six bolts. Use a hammer to drive three bolts through the holes in the sideplate, leaving the boltheads on the outside surface. Place a corner bracket over the ends of the three bolts. Use a washer and nut on each bolt to hold the bracket. Do not tighten the nuts at this time. Have one man hold the joists in place so that the holes in the joist line up with the holes in the corner bracket. Have a second man drive three bolts through the holes in the joist and the bracket. Use a washer and nut on each bolt. Do not tighten the nuts at this time. Install the three remaining brackets, using this same procedure. After the four brackets have been installed, tighten all nuts.

(5) Two runners (13) are to be installed under the skid framework. Raise one side of the skid on which a sideplate is located. Position one runner flush against the inside surface of the sideplate and permit the ends of the joists to rest on top of the runner. Keep the ends of the sideplate and the ends of the runner as even as possible. Raise the opposite side of the skid. Place the second runner under this side. Hold the runners firmly against the sideplates and, at approximately 8-inch intervals, drive a nail (8) through the sideplates and into the runners.

b. Assembly of Joists and Spreader Blocks.

(1) The two sideplates of the skid frame are 120 inches long. Measure in 60 inches from one end on both sideplates and mark these points. Draw a guideline across the 2-inch thickness of the sideplates at the marked points.

(2) Install two joists (7) between the sideplates with their ends resting on the runners. Position the joists so that their 8-inch sides are vertical and flush against each other and the joint between them is alined with the guidelines ((1) above). To hold each of the joists in place, drive three nails (8) through both sideplates and into the ends of the joist. Use one nail (8) on each side of the joists and toenail the ends of the joists to the runners.

(3) Use two spreader blocks (9) as spacers, and install two joists (7) between the sideplates, one to the right and one to the left of the installed joists ((2) above). Fasten these joists to the sideplates with three nails (8) at each end. Use two nails (8) at each end and toenail the joists to the runners.

(4) The distance from the outside of one sideplate to the outside of the other sideplate is 120 inches. On the four joists already installed, measure in 24 inches from the outside of one sideplate and draw a line across the 2-inch thickness of each joist. Measure in 60 inches from the outside of the same sideplate and again draw a line across the four joists.

(5) Install four spreader blocks (9) between the joists. Center two spreader blocks on the lines drawn across the joists at the 24-inch point. Center the other two spreader blocks on the lines drawn across the joists at the 60-inch point. Where the ends of the spreader blocks contact single joists, drive three nails (8) through the joists into the spreader blocks. Use three nails (8) and toenail the other ends of the spreader blocks to

the double joists across the center of the skid.

(6) Use two spreader blocks (10) as spacers, and install four more joists (7) between the sideplates, two on the right and two on the left of those already installed. Fasten these joists to the sideplates with three nails (8) at each end. Use two nails (8) at each end and toenail the joists to the runners.

(7) As stated in (4) above, lines were drawn across the thickness of four joists at a point 24 inches from the outside of one sideplate. On the four installed joists ((6) above) and the two joists that are part of the skid frame, measure in 24 inches from the outside of the opposite side plate and draw a line across the 2-inch thickness of each joist. Measure in 60 inches from the outside of the same sideplate and again draw a line across each of the six joists.

(8) Install four spreader blocks (10) and two spreader blocks (11) between the joists. Keep the centers of the spreader blocks on the lines drawn across the joists at the 24-inch point. Install four more spreader blocks (10) and two more spreader blocks (11) between the joists. Keep the centers of these spreader blocks on the lines drawn across the joists at the 60-inch point. At one end of each spreader block (11), drive three nails (8) through the joist and into the spreader block. At both ends of the remaining spreader blocks, use three nails (8) and toenail the spreader blocks to the joist.

c. Installation of Stringer.

(1) One centerline of the skid runs parallel to the sideplates. Spreader blocks have already been installed so that they are centered on this line. Lay the stringer (12) flat in the position shown. Block up the stringer so that it is flush against the underside of the spreader blocks and joists. Keep the stringer centered on the spreader blocks and the ends of the stringer even with the sides of the outside joists.

(2) Toenail the joists and spreader blocks to the stringer with nails (8). Use two nails on each side of the spreader blocks and one nail on each side of the joists.

d. Assembly of Plywood Top. Lay out the plywood sections (14–17) in their proper locations on top of the skid. When laid out properly, the joints between the sections of plywood will fall at the center of either joists or spreader blocks. Fasten one plywood section at a time to the skid. Use the nails (18) to hold the plywood sections in place. Drive the nails on approximately 6-inch centers around the edges of the plywood sections. Drive the nails (18) at approximately 12-inch intervals along the joists and spreader blocks which run under the plywood sections.

7. Preparation and Installation of Platform Skid MX–1918/FRN–22

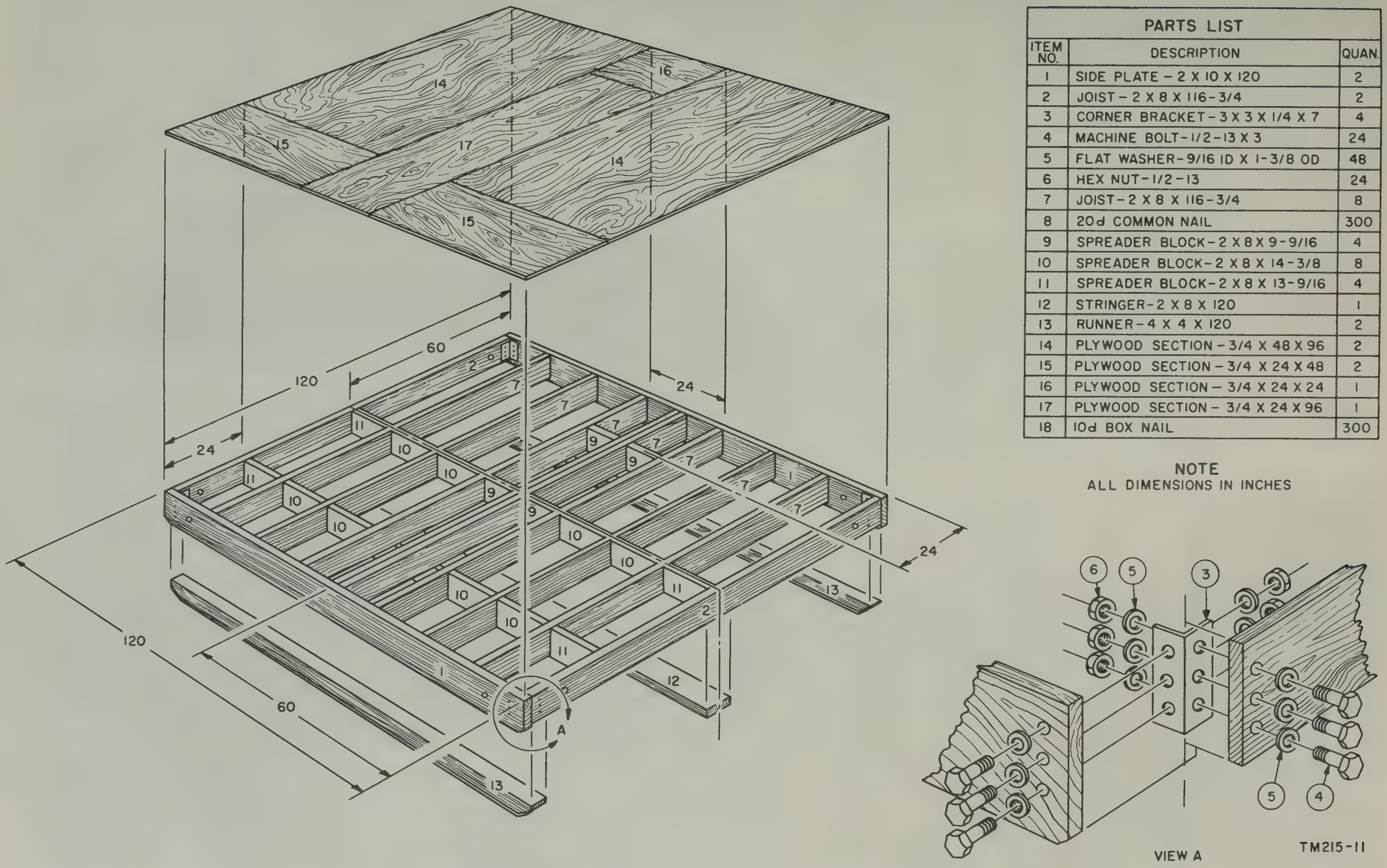
a. Draw a diagonal line between each pair of opposite corners of the skid. The point where the two lines cross is the center of the skid. Use the intersection as a center and draw one circle with a 9-inch radius and a second circle with a 56⅜-inch radius.

b. From the center point, measure out 12 inches on one of the diagonal lines. Make a mark on the diagonal line at the 12-inch point. Use the marked point as a center and draw a 2-inch radius circle. Just inside the circumference of the circle, drill a hole through the plywood large enough to clear the blade of a keyhole saw. Use a keyhole saw to cut out a hole represented by the circle. Use a wood file and bevel around the top of the hole to remove sharp edges.

c. Final positioning of the skid depends on the direction the shelter door will face. Where possible, see that the shelter door faces farthest from the point from which the prevailing winds blow. Since the shelter door must be located at the corner of the skid nearest the 4-inch hole (*b* above), turn this corner of the skid toward the direction the door is to face. Make sure the skid is resting on solid ground. Use a spirit level to level the skid.

8. Installation of Ground Rod

a. A 6-foot copper-jacketed steel rod is supplied with the omnirange set to provide an earth ground. Insert the rod through the 4-inch diameter hole cut in the plywood top of the skid (par. 7).



ITEM NO.	PARTS LIST DESCRIPTION	QUAN.
1	SIDE PLATE – 2 X 10 X 120	2
2	JOIST – 2 X 8 X 116-3/4	2
3	CORNER BRACKET – 3 X 3 X 1/4 X 7	4
4	MACHINE BOLT – 1/2-13 X 3	24
5	FLAT WASHER – 9/16 ID X 1-3/8 OD	48
6	HEX NUT – 1/2-13	24
7	JOIST – 2 X 8 X 116-3/4	8
8	20d COMMON NAIL	300
9	SPREADER BLOCK – 2 X 8 X 9-9/16	4
10	SPREADER BLOCK – 2 X 8 X 14-3/8	8
11	SPREADER BLOCK – 2 X 8 X 13-9/16	4
12	STRINGER – 2 X 8 X 120	1
13	RUNNER – 4 X 4 X 120	2
14	PLYWOOD SECTION – 3/4 X 48 X 96	2
15	PLYWOOD SECTION – 3/4 X 24 X 48	2
16	PLYWOOD SECTION – 3/4 X 24 X 24	1
17	PLYWOOD SECTION – 3/4 X 24 X 96	1
18	10d BOX NAIL	300

NOTE
ALL DIMENSIONS IN INCHES

Figure 3. Platform Skid MX-1918/FRN-22, assembly drawing.

b. Position the rod so that it is vertical and against the edge of the hole. To permit entry of necessary lines and cables through the hole, drive the rod as straight as possible into the ground until about 3 inches of the rod is left above the top of the skid.

9. Assembly of Electrical Equipment Shelter S–120/FRN–22

(figs. 4–6)

The assembly procedure for the shelter is given in *a* through *d* below.

a. Installation of Antenna Pedestal (fig. 4).

(1) Set the antenna pedestal in the center of the skid so that the circumference of the 9-inch radius circle drawn on the skid shows through the slots in the base of the pedestal. Rotate the antenna pedestal until the circuit breaker boxes mounted on the pedestal (fig. 201) are above the 4-inch diameter hole and face directly toward the corner of the skid.

(2) Drill a ¼-inch diameter hole into the skid through the center of each of the 12 slots in the base of the antenna pedestal.

(3) Use twelve ½- by 1½-inch lag screws and twelve 9⁄16-inch inside diameter by 1⅜-inch outside diameter washers to hold the pedestal in place. Start a lag screw in each of the 12 holes ((2) above). Use a ratchet wrench (or a motor-driven impact tool if available) and a 29⁄32-inch 12-point socket to partially tighten the lag screws. Do not tighten the lag screws completely because it may be necessary to rotate the pedestal slightly during later stages of shelter assembly.

b. Assembly of Shelter Wall Sections (fig. 4).

(1) Six curved wall sections form the sides of the shelter. Start with the wall section containing a cutout for the shelter blower. Position this wall section so that the holes in its bottom flange are on the circumference of the 56⅜-inch radius

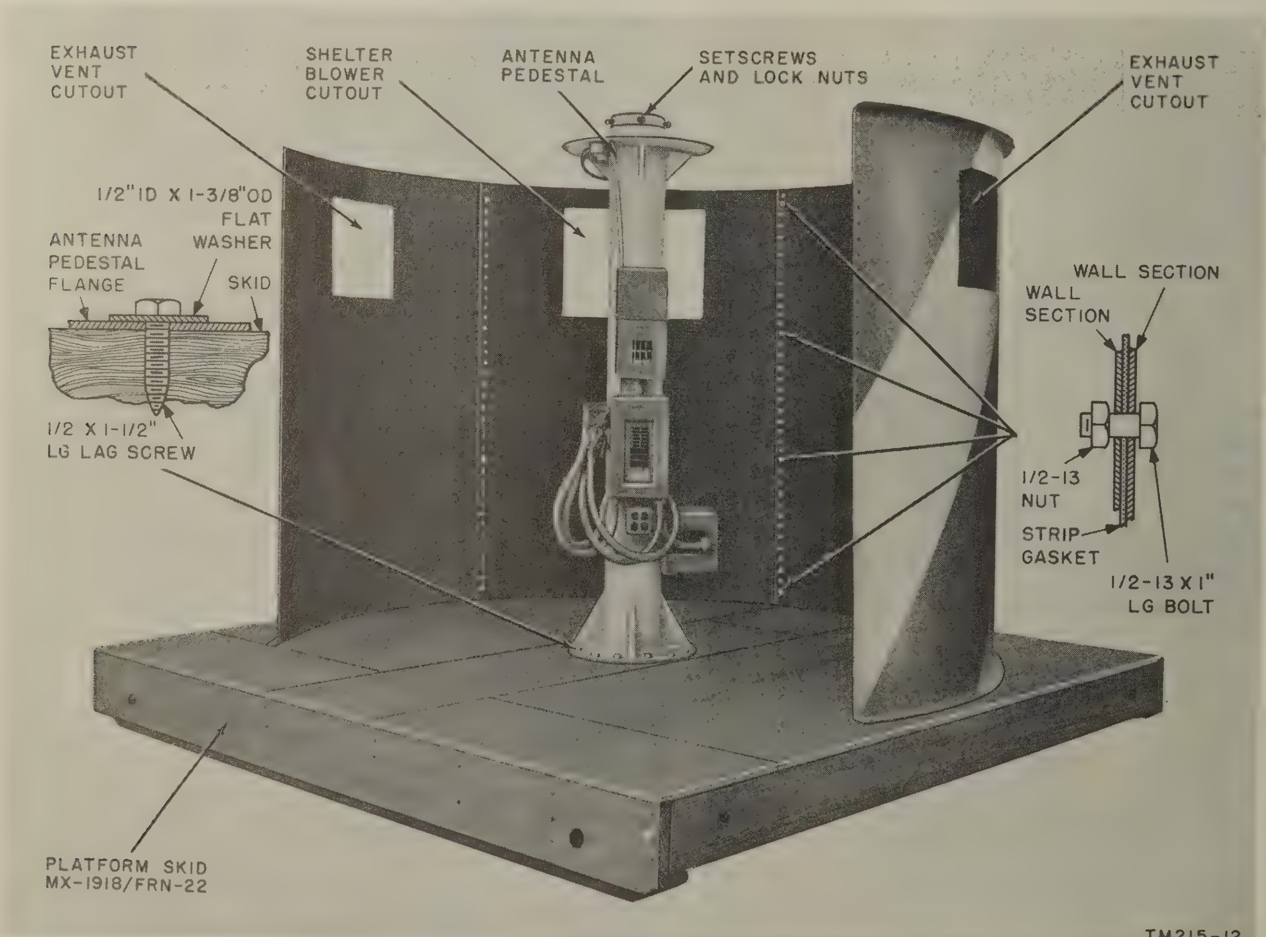


Figure 4. Electrical Equipment Shelter S–120/FRN–22, assembly view No. 1.

circle drawn on the skid, and the center of the wall section is directly behind the pedestal when viewed from a point facing the circuit breaker boxes on the pedestal.

(2) Place the second wall section to the left of the first wall section, as viewed from inside shelter. Either of the two wall sections containing a cutoff for an exhaust vent can be used in this location. Hold the first section upright and position the next section so that its edge fits over the edge of the first section to form a lap joint. Use driftpins to line up the holes in the overlapping edges of the wall sections. While the two wall sections are held upright, insert four ½–13 by 1-inch bolts through equally spaced holes in the lap joint from outside the shelter. Hold the boltheads to keep them from turning while the nuts are threaded on from inside the shelter. Leave the nuts and bolts loose; their only purpose is to hold the wall sections together temporarily.

(3) Working toward the left, as viewed from inside the shelter, continue with the assembly of the wall sections. Raise one wall section at a time, and attach it to the preceding wall section with the four bolts and nuts as described in (2) above. Assemble the remaining wall sections in the following order:

(*a*) Wall section without cutouts.
(*b*) Wall section containing shelter door.
(*c*) Wall section containing cutout for exhaust vent.
(*d*) Other wall section without cutouts.

c. Assembly of Shelter Roof Sections (fig. 5).

(1) Six stiffeners must be bolted to the underside of each of the two roof sections before the roof sections are put in place. Each roof stiffener has two flanges which are turned in opposite directions. Four boltholes are spaced along each flange. As shown, the flange bolted to the roof section is turned toward the left. Four ½–13 by 1-inch bolts, recessed washers, ring gaskets, and nuts are used to fasten each stiffener in place. Stand one roof section upright on its straightedge. Hold the roof stiffener against the black painted side of the roof section, and aline the holes in the stiffener with the holes in the roof section. Place a recessed washer and ring gasket on each bolt, and insert the bolts through the holes from the opposite side of the roof section. Thread the nuts on the bolts. When the six roof stiffeners are in place, use a ratchet wrench or impact tool and a $^{29}/_{32}$-inch 12-point socket to tighten all bolts securely. Use this same procedure to fasten the six stiffeners to the second roof section.

(2) Raise one roof section and place it on top of the wall sections. Position the section so that the semicircular cutout in its straightedge rests on the flange on top of the pedestal and the straightedge bisects the shelter at the middle of two opposite wall sections.

(3) Three 120° segments of rubber gasket material are used around the pedestal flange to provide a seal between the flange and the two roof sections. Two men are needed to install these gasket segments and bolt the roof sections to the pedestal flange. First, obtain a 7-foot plank, or other suitable material, capable of safely supporting the weight of one man. Lay this plank across the unroofed portion of the shelter with one end of the plank resting on the pedestal flange; station one man on this plank. The second man, inside the shelter, holds the roof section up away from the pedestal flange. The man on top of the shelter overlaps one gasket segment with another by the space of one hole and positions both segments under the roof section so that the excess lengths protrude from under the roof section by approximately equal amounts. Use three ½–13 by 1-inch bolts, recessed washers, ring gaskets, and nuts to fasten the roof section to the pedestal flange. The man on top of the shelter places a recessed washer and ring gasket on each bolt and inserts the bolts through the three holes near the center of the semicircular cutout in the roof section. The man inside the shelter threads the nuts on the bolts. Tighten the bolts securely. Re-

move the plank from the top of the shelter.

(4) Raise the remaining roof section to the top of the shelter. Position this section so that its straightedge overlaps the straightedge of the first roof section. Station one man on top of the first roof section and a second man inside the shelter. The rubber strip gasket to be used between overlapping edges of the roof sections is supplied in rolls. The man inside the shelter lifts the straightedge of the top roof section. The man on top of the shelter inserts the rubber strip gasket, cut to proper length, between the overlapping straightedges on each side of the antenna pedestal. If necessary, use driftpins to aline the holes in the gasket and roof sections. Insert ½–13 by 1-inch bolts through several holes to keep the holes alined. Insert the remaining 120° gasket segment between the top roof section and the pedestal flange. On each side of the antenna pedestal, install an offset gasket between the lap joint in the shelter roof and the gasket segments on the pedestal flange.

(5) To fasten the roof sections to the pedestal flange, use ⅜–16 by 1-inch bolts, with recessed washers, ring gaskets, and nuts at the holes where the roof sections overlap. Use ½–13 by 1-inch bolts, recessed washers, ring gaskets, and nuts at all other holes in the pedestal flange. Tighten all bolts securely.

(6) Fasten the overlapping edges of the roof sections together with ½–13 by 1-inch bolts, recessed washers, ring gaskets, and nuts. Tighten the bolts securely.

d. Final Assembly of Shelter (fig. 5).

(1) Bolt the wall sections together permanently. Complete the work at one lap joint before moving to the next. At each lap joint, insert a length of rubber strip gasket between the wall sections and use a channel strip inside the shelter to keep the nuts from turning. Use a ½–13 by 1-inch bolt, recessed washer, ring gasket, and nut at each hole in the vertical portion of the lap joint. Leave the holes in the top and bottom flanges open. Do not tighten the bolts until the bolts are in place in every lap joint; then tighten all bolts securely.

(2) Aline the boltholes in the circumference of the shelter roof with the boltholes in the top flanges of the wall sections by shifting the wall sections and/or rotating the pedestal. Use driftpins to help with the final alinement of the boltholes. Install an offset gasket at each lap joint between the wall sections and at the two points where the overlapping roof sections meet the shelter walls. Insert the strip gasket between the roof and wall sections completely around the shelter. To fasten the roof to the wall sections, use ⅜–16 by 1-inch bolts with recessed washers, ring gaskets, and nuts at holes in the wall lap joints and holes where the roof sections overlap. Use ½–13 by 1-inch bolts, recessed washers, ring gaskets, and nuts at all other holes around the roof circumference.

(3) Adjust the lower portions of the wall sections so that the holes in their bottom flanges are centered, as nearly as possible, over the 56⅜-inch radius circle drawn on the skid. Drill one ¼-inch pilot hole into the skid through the hole in each wall section lap joint, and additional ¼-inch holes through every third hole in each wall section flange.

(4) Use a pry bar to raise the bottom flange of one wall section. Insert one end of a roll of rubber strip gasket between the flange and the skid, and install an offset gasket at the lap joints. Install a ½- by 1½-inch lag screw, recessed washer, and ring gasket at each hole previously drilled into the skid. Tighten the lag screws securely. Continue this process completely around the shelter.

(5) After the shelter assembly is completed, use a spirit level to make sure the pedestal is vertical. If necessary, drive shims under the pedestal base to straighten it. When the pedestal is vertical, tighten securely the 12 lag screws at the pedestal base. Recheck the vertical alinement of the pedestal after the lag screws are tightened.

(6) A caulking gun is supplied with the shelter. On the inside of the shelter,

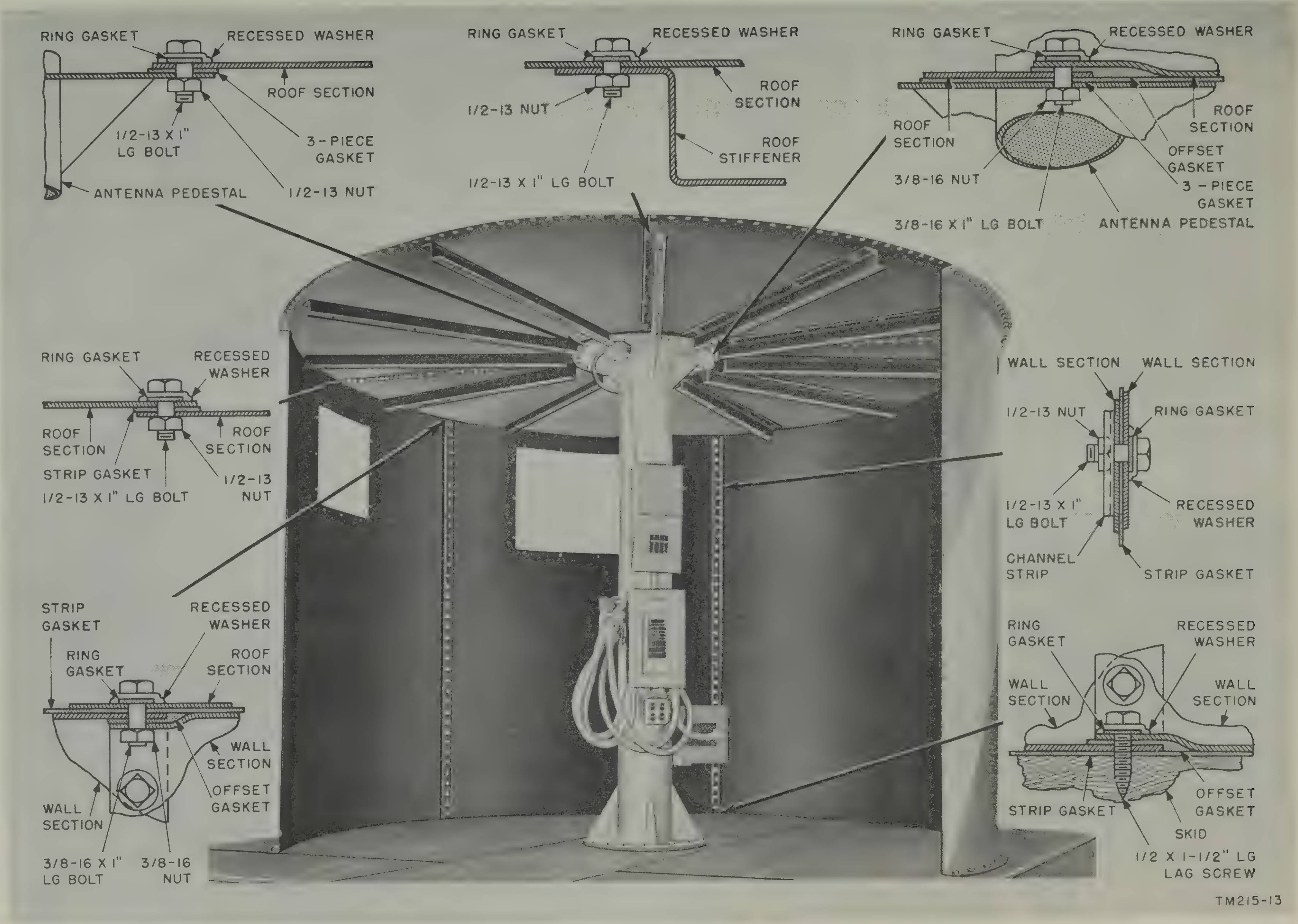


Figure 5. Electrical Equipment Shelter S-120/FRN-22, assembly view No. 2.

apply caulking compound to the joints formed by the wall sections and roof, antenna pedestal and roof, wall sections and skid, and to the joints between the wall sections. Save some of the caulking compound for use around the shelter blower and exhaust vents after they are installed (par. 10).

10. Installation of Propeller Ventilating Fan HD–244/FRN–22

(fig. 6)

a. Remove the roll of rubber strip gasket and the bag of mounting hardware from the bar-type grill of the shelter blower. Leave the flexible conduit attached to the grill.

b. The upper mounting flange for the shelter blower was removed to facilitate packing. Position the upper mounting flange on the blower housing so that the four holes in one edge are alined with the four holes in the top of the blower housing. Fasten the mounting flange to the blower housing with the four ¼–20 by ⅝-inch capscrews, lockwashers, and nuts. Tighten all screws securely.

c. Inside the blower housing are two electrostatic air filters in cardboard cartons and two louvered exhaust vents. Loosen the two knurled thumbscrews which hold the rear panel of the blower housing in place. Pull the panel outward to clear the lock hasp and pull it downward to remove the top edge of the panel from under the flange on the blower cover.

d. Cut and remove the metal strap from around

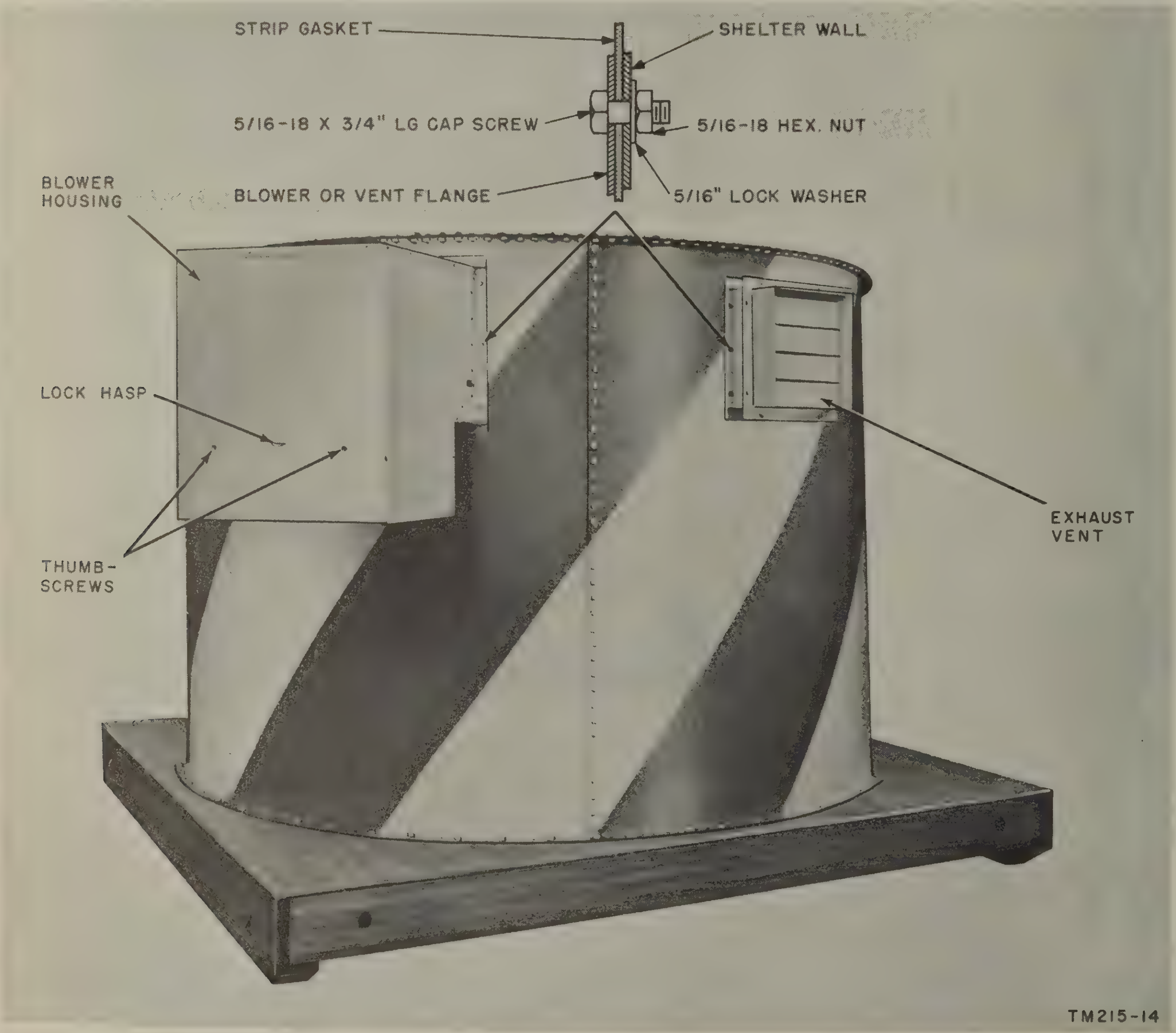


Figure 6. Propeller Ventilating Fan HD–244/FRN–22, installation view No. 1.

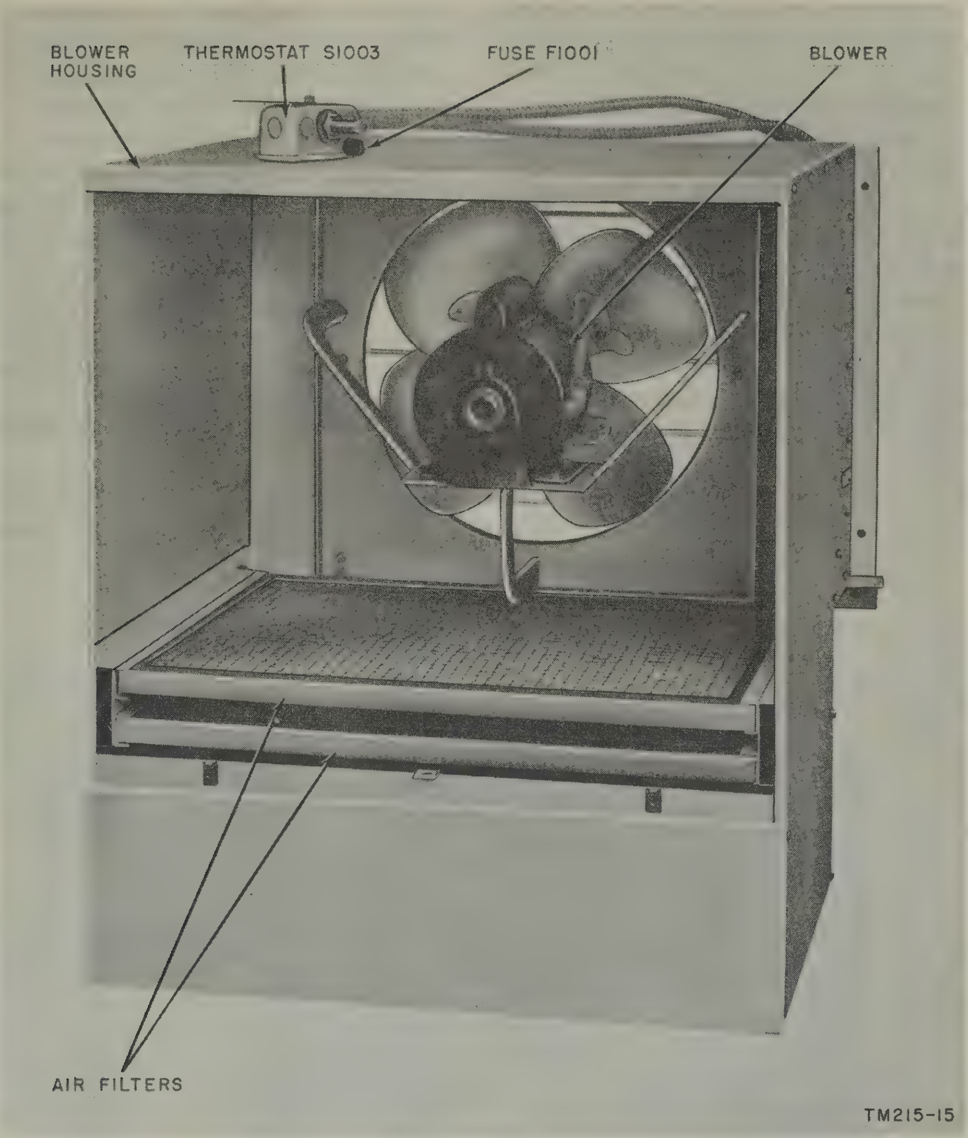


Figure 7. Propeller Ventilating Fan HD–244/FRN–22, installation view No. 2.

the exhaust vents. Remove the exhaust vents and air filters.

e. Insert a length of rubber strip gasket between each of the four shelter blower mounting flanges and the shelter wall section. Match the holes in the roll of strip gasket with the holes in the mounting flange and cut the gasket to the proper length.

f. Mount the shelter blower to the shelter as shown in figure 6. Use some of the strip gasket previously cut for the upper mounting flange (*e* above). Two men raise the blower and hold it in position. A third man inserts the gasket and guides the 5/16–18 by 3/4-inch capscrews through the holes in the flange through the gasket and the shelter wall section. A fourth man, inside the shelter, places lockwashers and nuts on the screws. Tighten the screws just enough to hold the blower in place. Install lockwashers and nuts on the remaining screws in the upper flange but leave the nuts slightly loose.

g. Use strip gaskets, 5/16–18 by 3/4-inch capscrews, lockwashers and nuts and fasten the three remaining flanges to the shelter wall section. When all screws are in place, tighten all nuts securely.

h. Install the two electrostatic filters in the blower housing as shown in figure 7. Be sure the airflow arrows on the sides of the filters point toward the top of the blower housing.

i. Replace the rear panel of the blower housing. Tighten the two knurled thumbscrews to hold the panel in place.

j. Use the method described in *e* above and cut the rubber strip gasket to fit the mounting flanges on the two exhaust vents.

k. Mount the exhaust vents to the wall sections as shown in figures 4 and 6. Use the rubber strip gasket between the vent mounting flanges and the wall section. Fasten the vents to the wall sections with the 5/16–18 by 3/4-inch capscrews, lockwashers, and nuts. Tighten all screws securely.

l. From inside the shelter, remove the wires which fasten the flexible conduit to the bar-type grill of the shelter blower. Lay the flexible conduit along the top of the roof stiffener flange nearest the point where the conduit emerges from the blower housing (fig. 8). At several points, clamp or lash the conduit to the stiffener. Make a partial loop around the antenna pedestal and fasten the mounting plate on the fuse and thermostat box to a roof stiffener with a 1/2–13 by 1-inch bolt, lockwasher, and nut.

m. Make all connections to the circuit breaker boxes on the antenna pedestal at one time. Tie the free end of the flexible conduit to the antenna pedestal to keep it out of the way until needed.

n. On the inside of the shelter, use the caulking gun and apply caulking compound to the joints around the shelter blower and the exhaust vents.

11. Installation of Antenna AT–669/FRN–22

(fig. 1, TM 11–5825–205–12)

a. The fixture portion of the obstruction light is mounted on top of the antenna at the factory.

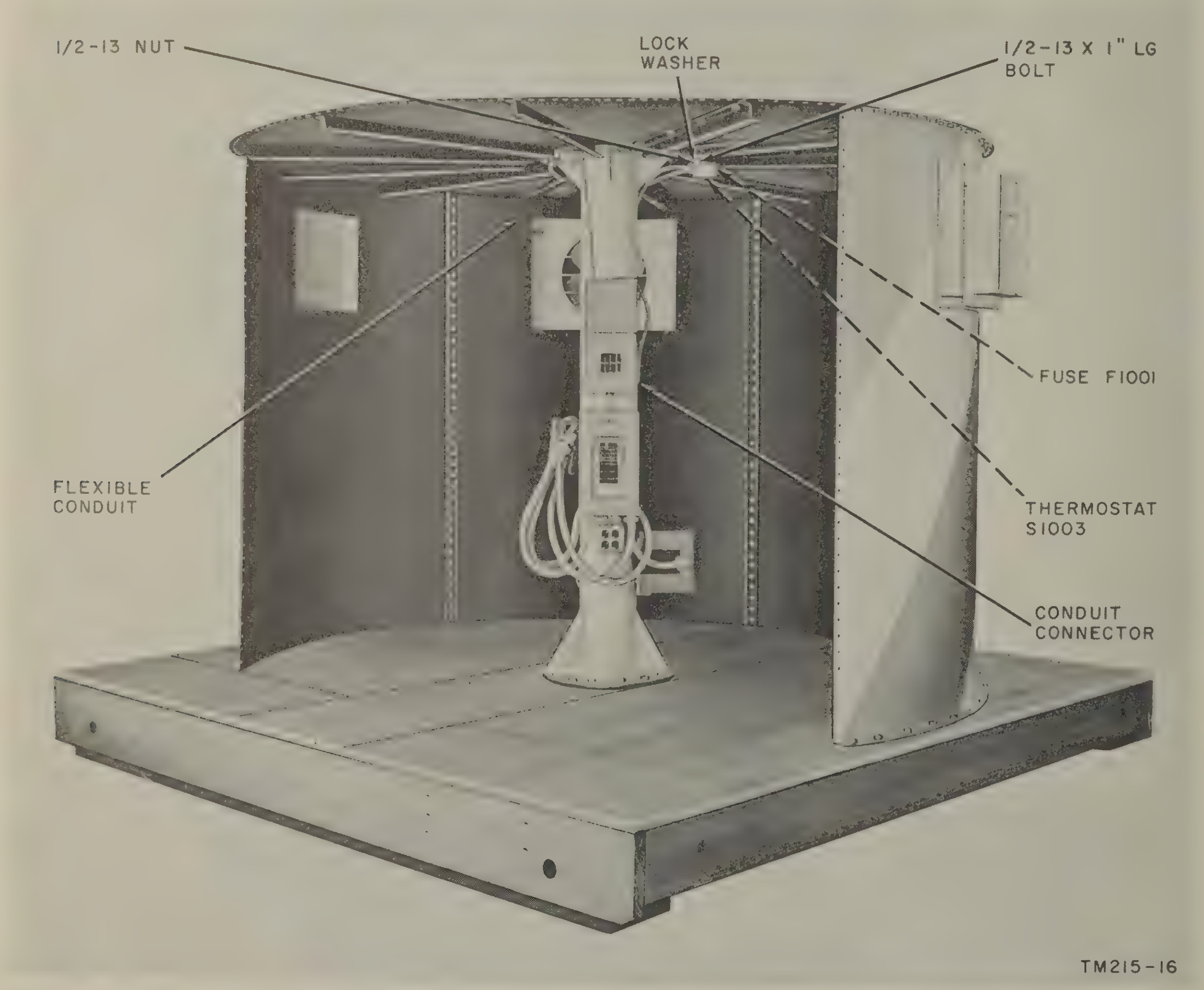


Figure 8. Propeller Ventilating Fan HD–244/FRN–22, installation view No. 3.

The two traffic signal bulbs and two red glass light lenses for the obstruction light are packed with the antenna. Screw a traffic signal bulb into the socket in each branch of the obstruction light fixture. Place a red light lens over each bulb and screw the lens into the fixture until it seats firmly against the rubber gasket inside.

***Caution:* When placing the antenna on the shelter roof (*b* below), be very careful that the bolts in the roof do not puncture the antenna radomes.**

b. The antenna mounts above the shelter roof and fits into the top of the antenna pedestal. Lift the antenna and carefully lay it on the shelter roof.

c. Five cables extend from the open end of the antenna support pipe. Insert the cables back into the support pipe opening. Push the cables into the support pipe until only a short portion of each cable extends beyond the end of the pipe opening. This will protect the cables and connectors from possible damage as the antenna is installed.

d. Raise the antenna to an upright position and ease the antenna support pipe down inside the pedestal until it rests on the flange inside the pedestal.

e. Set up a surveyor's transit 200 or 300 feet from the north side of the shelter. A portion of the antenna support pipe is visible between the body of the antenna and the shelter roof. Sight through the transit and, *keeping the transit alined on the center of the support pipe*, shift the transit until it is aligned on a bearing of 180° magnetic. Rotate the antenna until the vertical black mark and the letter N (near the nameplate) are *centered* in the transit. Use a ¼-inch sockethead wrench to tighten the four setscrews around top of antenna pedestal (fig. 4). Use a ¾-inch wrench to tighten the locknuts on the setscrews.

f. From inside the shelter, reach through the access hole at the rear of the pedestal and pull the five antenna cables through the hole. Coil the ends of the cables to keep them out of the way until instructions are given on how to connect them.

12. Location and Installation of Antenna Group AN/FRA–14

(figs. 1 and 9)

a. Locate the AN/FRA–14 within 20° of north, south, east, or west. Select the position which is the greatest distance from obstructions, runways, taxiways, or aircraft ramps. Measure 100 feet from the antenna and mark this point.

b. The mounting post for the AN/FRA–14 is not supplied with the omnirange set. The post should be of a nonmetallic material not over 4 inches square and long enough so that when it is installed a 10-foot portion will remain above ground level, with enough extra length below ground level to provide a firm base. A wooden 4-by 4-inch post 16 to 20 feet long should be sufficient for this purpose. A wood preservative should be applied to the portion of the post which is placed in the ground and the portion above ground should be painted to protect it from the weather. At the 100-foot point (*a* above), dig a hole for the post. Install the post *with one of its flat sides facing directly toward the center of the antenna on the shelter.* Where necessary, use cement around the base of the post, or use nonmetallic guying materials to hold the post vertical.

c. Mount the folded dipole for the AN/FRA–14 on the case as shown in figure 9. Remove the outside nut and lockwasher from studs protruding from the standoff insulators on each side of the case. Remove the two capscrews and lockwashers which hold the clamping bar in place; remove the clamping bar. Fit the ends of the dipole over the studs protruding from the standoff insulators. Place a nut and lockwasher on each stud to retain the ends of the dipole, but do not tighten the nuts. Seat the middle of the dipole into the depression in the dipole support block on top of the case. Place the clamping bar over the middle of the dipole and fasten it in place with the two capscrews and lockwashers. Tighten the nuts to hold the ends of the dipole in place.

d. Use the four bolts and clamping plate supplied and fasten the AN/FRA–14 at the top of its mounting post on the side facing the antenna on the shelter.

13. Installation of Equipment in Electrical Equipment Shelter S–120/FRN–22

Installation of equipment in the shelter consists of positioning the equipment cabinets in the shelter, installing panels and components in each cabinet, and installing the shelter lights. Perform the operations outlined below.

***Warning:* Some of the individual components to be installed in equipment cabinets are quite**

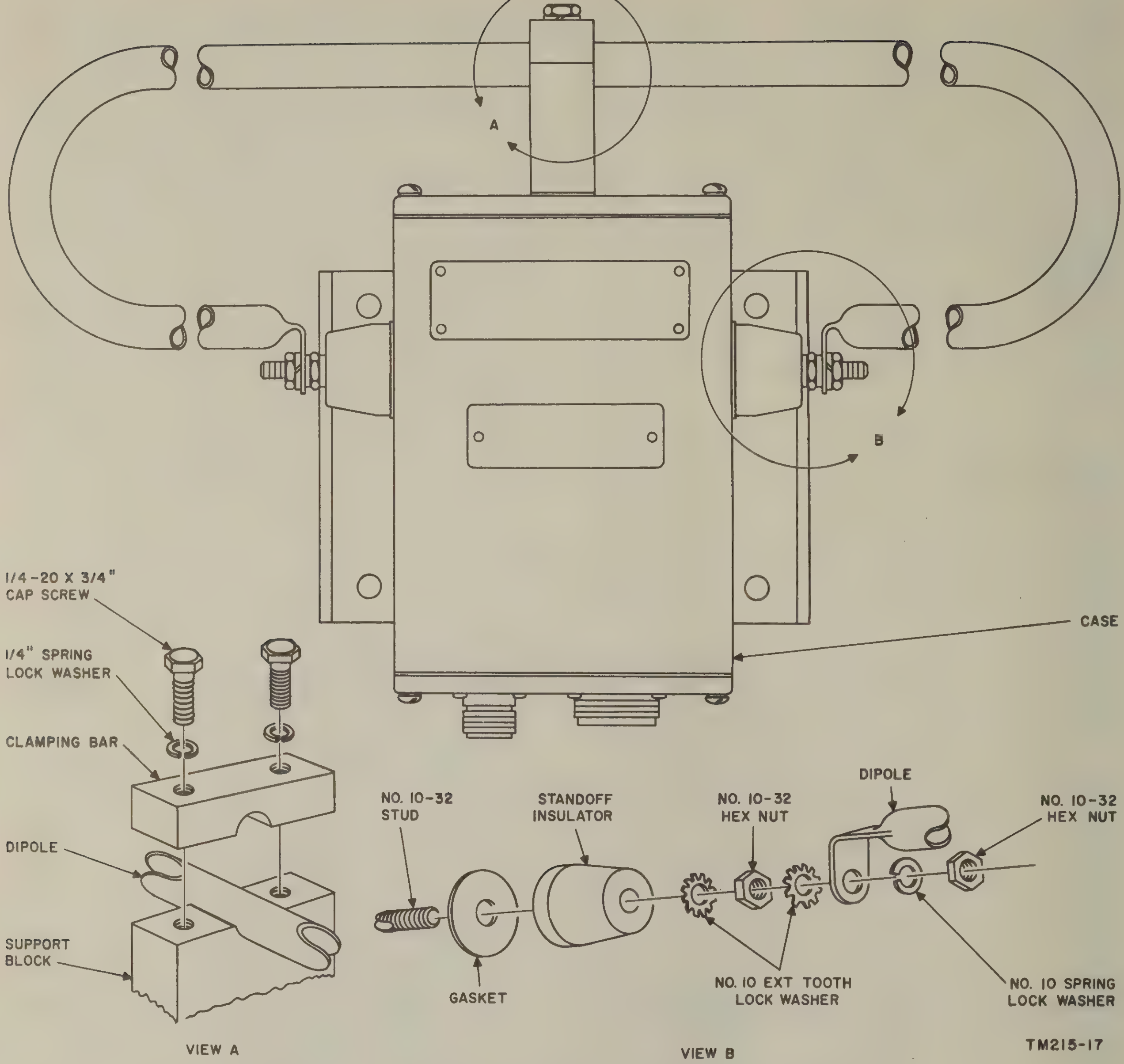


Figure 9. Antenna Group AN/FRA-14, installation of dipole.

heavy. To prevent injury to personnel or damage to equipment, use sufficient personnel to safely accomplish installation of these components.

a. Figure 10 shows the relative location of each cabinet within the shelter. Individual cabinets can be recognized by referring to the identification plate located above the opening in the front of the cabinet. The rear door of each equipment cabinet is hung on separable hinges. Remove the rear door from each of the four cabinets by first opening the door and then lifting it straight up and off the hinge pins. Leave the doors in a safe place outside the shelter while the cabinets and components are being installed.

b. Move the No. 1 CY-1899/FRN-22 into the shelter and position it as shown in figure 10. Remove the trim strips and envelopes of hardware from inside the cabinet.

c. Figure 11 shows where the components and blank panel are to be installed in the CY-1899/FRN-22. Slip the speed nuts over the holes in the cabinet flanges at points where the components and panel are to be fastened. Start at the bottom of the cabinet and fasten the components and panel to the cabinet with the 10 by ⅝-inch sheet

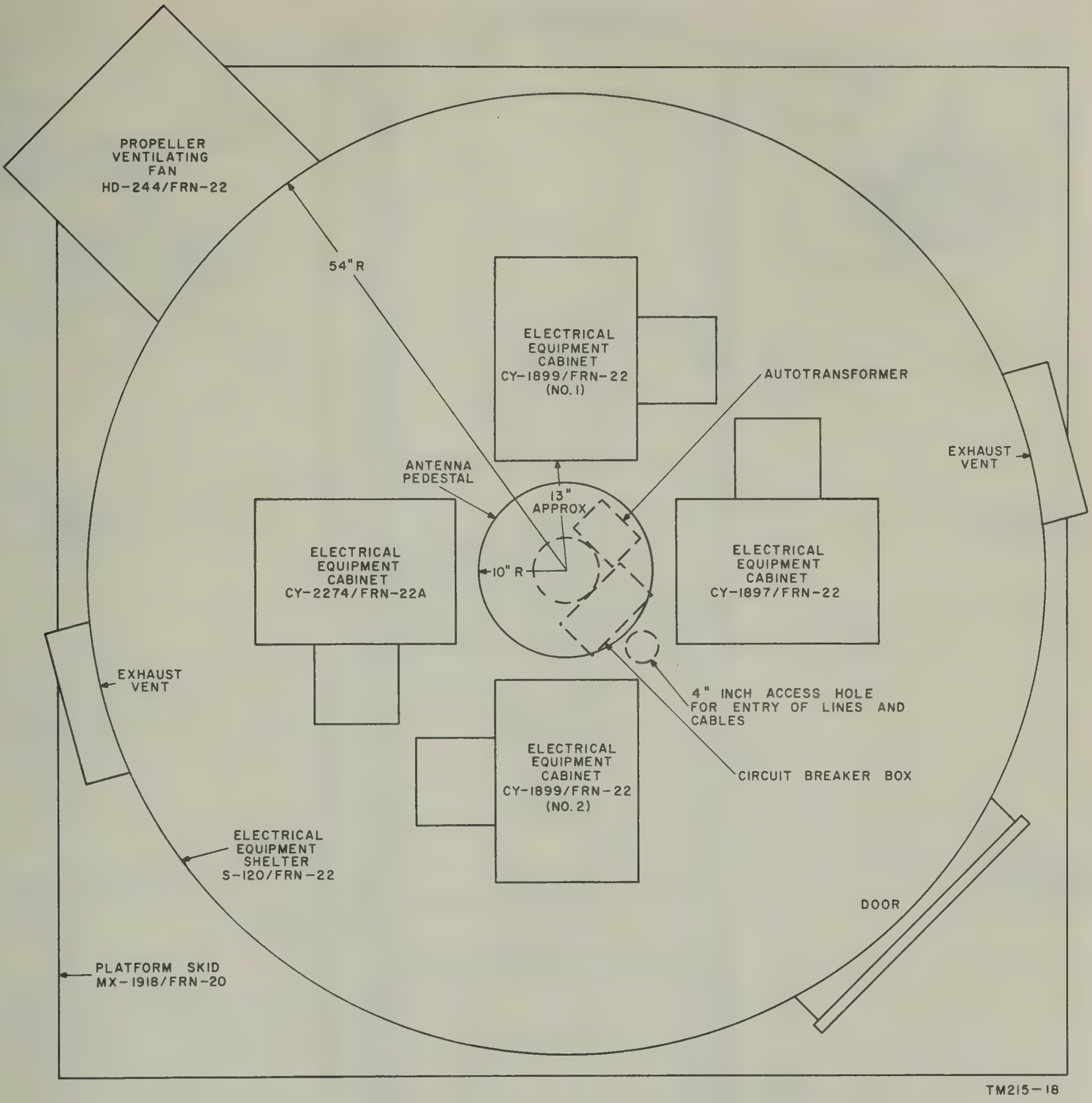

PROPELLER VENTILATING FAN HD-244/FRN-22
54" R
ELECTRICAL EQUIPMENT CABINET CY-1899/FRN-22 (NO. 1)
AUTOTRANSFORMER
EXHAUST VENT
ANTENNA PEDESTAL
13" APPROX
ELECTRICAL EQUIPMENT CABINET CY-2274/FRN-22A
10" R
ELECTRICAL EQUIPMENT CABINET CY-1897/FRN-22
EXHAUST VENT
4" INCH ACCESS HOLE FOR ENTRY OF LINES AND CABLES
ELECTRICAL EQUIPMENT CABINET CY-1899/FRN-22 (NO. 2)
CIRCUIT BREAKER BOX
ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
DOOR
PLATFORM SKID MX-1918/FRN-20
TM215-18

Figure 10. Electrical Equipment Shelter S–120/FRN–22, floor layout.

metal screws. Use the trim strip clips at locations shown in the figure.

d. To mount the cabinet trim strips, hold a trim strip in position with one edge of the strip under one side of the trim strip clips. Tap the trim strip with a rubber or padded hammer at each clip to snap the strip into place.

e. Move the CY–2274/FRN–22A into the shelter and position it as shown in figure 10. Remove the trim strips and envelopes of hardware from inside the cabinet.

f. Figure 12 shows where components and blank panels are to be installed in the CY–2274/FRN–22A. Slip the speed nuts over the holes in the cabinet flanges at the points where components and panels are to be fastened. Start at the bottom of the cabinet and fasten the components and panels to the cabinet with the No. 10 by ⅛-inch sheet metal screws. Use the trim strip clips at the locations shown in the figure. Mount the cabinet trim strips as described in *d* above.

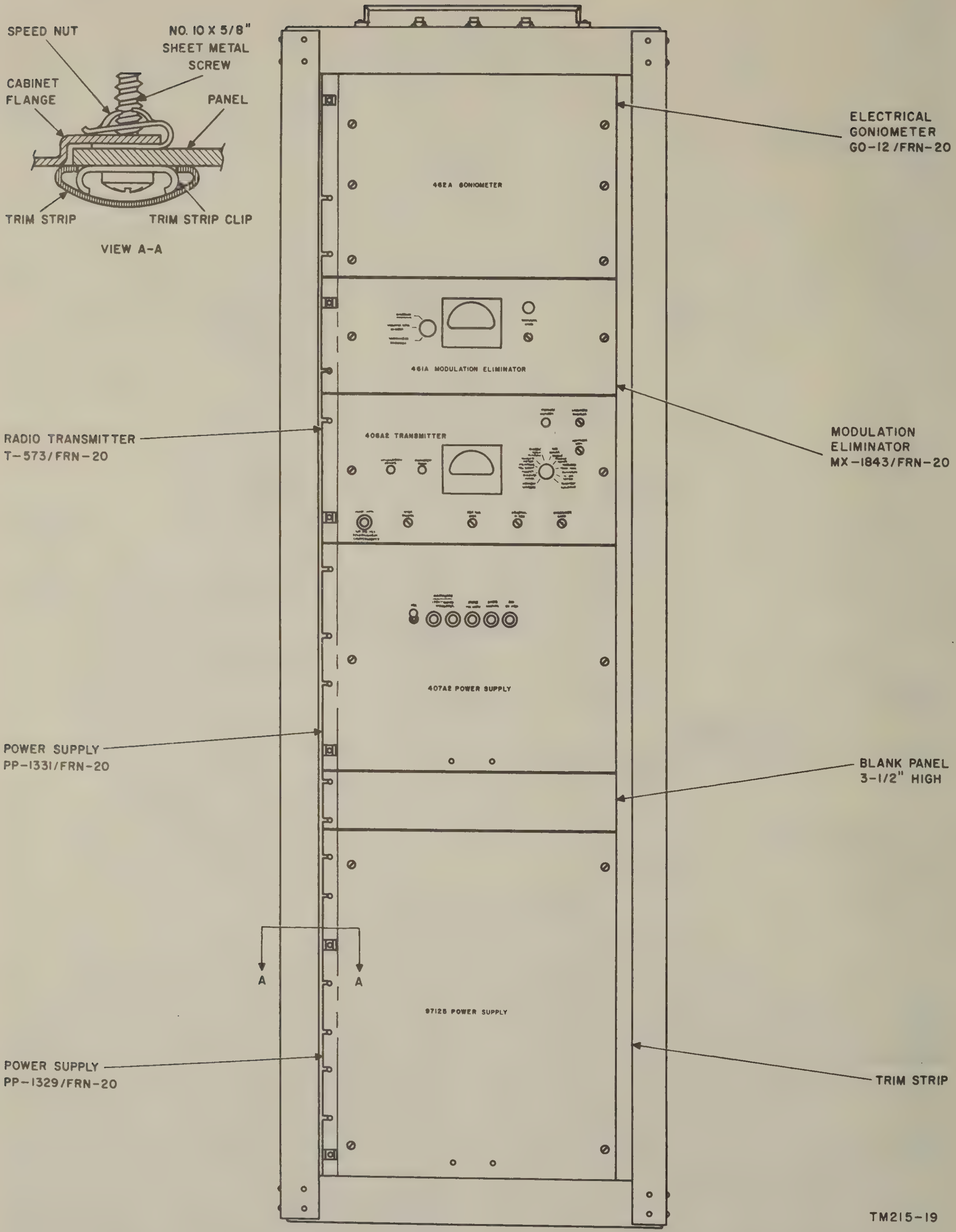

SPEED NUT
NO. 10 X 5/8" SHEET METAL SCREW
CABINET FLANGE
PANEL
TRIM STRIP
TRIM STRIP CLIP
VIEW A-A
ELECTRICAL GONIOMETER GO-12/FRN-20
462A GONIOMETER
461A MODULATION ELIMINATOR
MODULATION ELIMINATOR MX-1843/FRN-20
RADIO TRANSMITTER T-573/FRN-20
406A2 TRANSMITTER
407A2 POWER SUPPLY
POWER SUPPLY PP-1331/FRN-20
BLANK PANEL 3-1/2" HIGH
A
A
9712B POWER SUPPLY
POWER SUPPLY PP-1329/FRN-20
TRIM STRIP
TM215-19

Figure 11. Electrical Equipment Cabinet CY-1899/FRN-22, component installation diagram.

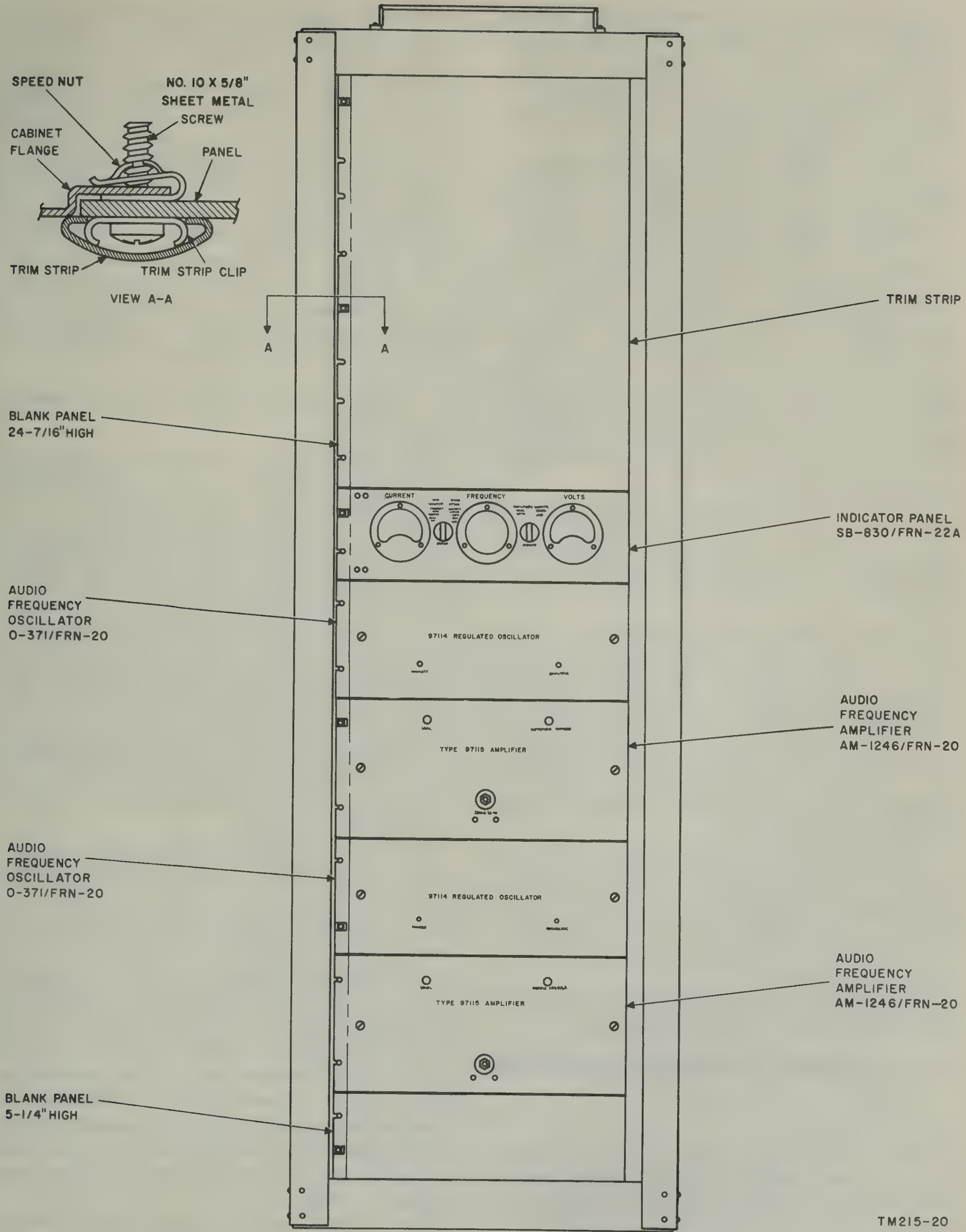

SPEED NUT
NO. 10 X 5/8" SHEET METAL SCREW
CABINET FLANGE
PANEL
TRIM STRIP
TRIM STRIP CLIP
VIEW A-A
A
A
TRIM STRIP
BLANK PANEL 24-7/16" HIGH
CURRENT
FREQUENCY
VOLTS
INDICATOR PANEL SB-830/FRN-22A
AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
97114 REGULATED OSCILLATOR
AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
TYPE 97115 AMPLIFIER
AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
97114 REGULATED OSCILLATOR
AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
TYPE 97115 AMPLIFIER
BLANK PANEL 5-1/4" HIGH
TM215-20

Figure 12. Electrical Equipment Cabinet CY-2274/FRN-22A, component installation diagram.

g. Move the No. 2 CY–1899/FRN–22 into the shelter and position it as shown in figure 10. Remove the trim strips and envelopes of hardware from inside the cabinet. Use the procedure described in *c* and *d* above to install the components, blank panel, and trim strips.

h. Move the CY–1897/FRN–22 into the shelter and position it as shown in figure 10. Remove the packaged cables, trim strips, and envelopes of hardware from inside the cabinet. Store the packaged cables in a safe place until required for making connections to components in the cabinet.

i. A handset mounting bracket is fastened to the inside of the right wall of the CY–1897/FRN–22 by two 8–32 by ½-inch machine screws, lockwashers, and nuts. Remove the handset mounting bracket, machine screws, lockwashers, and nuts. Use the same two holes and mounting hardware and fasten the bracket on the outside of the cabinet (fig. 13).

j. Figure 13 shows where the components and blank panels are to be installed. Slip the speed nuts over the holes in the cabinet flanges at the points where components and panels are to be fastened.

k. Loosen the six front-panel screws on the voltage regulator (fig. 13) and set it in the bottom of the CY–1897/FRN–22. Make certain that the chassis is seated solidly. Adjust the front panel on its slotted brackets so that the panel rests on the flange across the bottom of the cabinet opening. Tighten the six front-panel screws and fasten the panel to the cabinet with the 10 by ⅝-inch sheet metal screws.

l. Start with the blank panel above the voltage regulator and fasten the remaining components and panels to the cabinet with the sheet metal screws. Use the trim strip clips at the locations shown in figure 13. Mount the trim strips as described in *d* above.

m. Screw the 100-watt light bulbs into the two sockets at the top of the antenna pedestal.

14. Installation of Branched Wiring Harness W19

(fig. 14)

Figure 14 shows how branched wiring harness W19 is to be installed between the four equipment cabinets. Directions for connecting individual wires of W19 will be given later.

a. Remove the bushing from the conduit nipple. Insert the threaded portion of the conduit nipple and the ends of the inclosed wires through the hole nearest the rear in the side of the No. 1 CY–1899/FRN–22. Replace the bushing on the end of the conduit nipple and, with the junction box parallel with the shelter floor, tighten the bushing securely.

b. Remove the locknut from the connector on the shortest length of flexible conduit extending from the junction box. Insert the threaded portion of the connector and the ends of the inclosed wires through the hole nearest the rear in the side of the CY–1897/FRN–22. Replace the locknut on the connector and tighten it securely. Use the same procedure to install the remaining two flexible conduits to the equipment cabinets.

15. Installation of Flexible Power Conduits

(fig. 15)

Five flexible power conduits extend from the lower circuit breaker box on the antenna pedestal. Figure 15 shows how these conduits are to be installed between the circuit breaker box and the four equipment cabinets. Directions for connecting individual wires contained in the flexible power conduits will be given later.

a. A ¾-inch flexible conduit containing three #14 AWG wires extend from the lower right-rear corner behind the circuit breaker box. Remove the locknut from the connector on the free end of the conduit. Insert the three wires and the threaded portion of the conduit connector through the hole nearer the front on the lower-left side of the CY–2274/FRN–22A. Replace and tighten the locknut.

b. Two ¾-inch flexible conduits, each containing five #14 AWG wires, extend from the left side of the bottom of the circuit breaker box. Remove the locknut from the connector on the free end of the rear conduit. Insert the five wires and the threaded portion of the conduit connector through the hole nearer the front of the lower-right side of the No. 1 CY–1899/FRN–22. Replace and tighten the locknut. Remove the locknut from the connector on the free end of the front conduit. Insert the five wires and the threaded portion of the conduit connector through the hole nearer the front on the lower-right side of the No. 2 CY–1899/FRN–22. Replace and tighten the locknut.

c. A ¾-inch flexible conduit containing eight #18 AWG wires extends from the right-front corner of the bottom of the circuit breaker box.

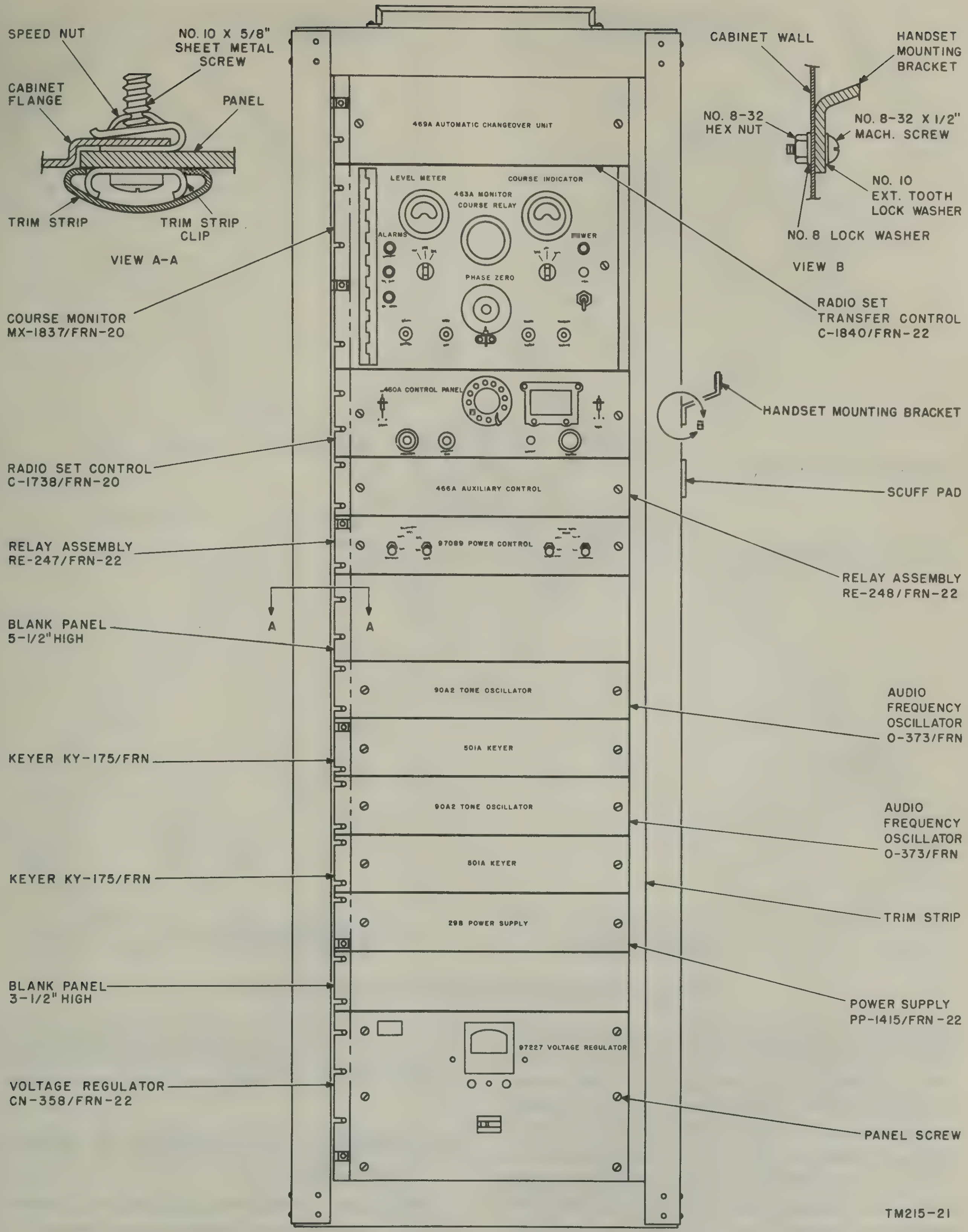


Figure 13. Electrical Equipment Cabinet CY-1897/FRN-22, component installation diagram.

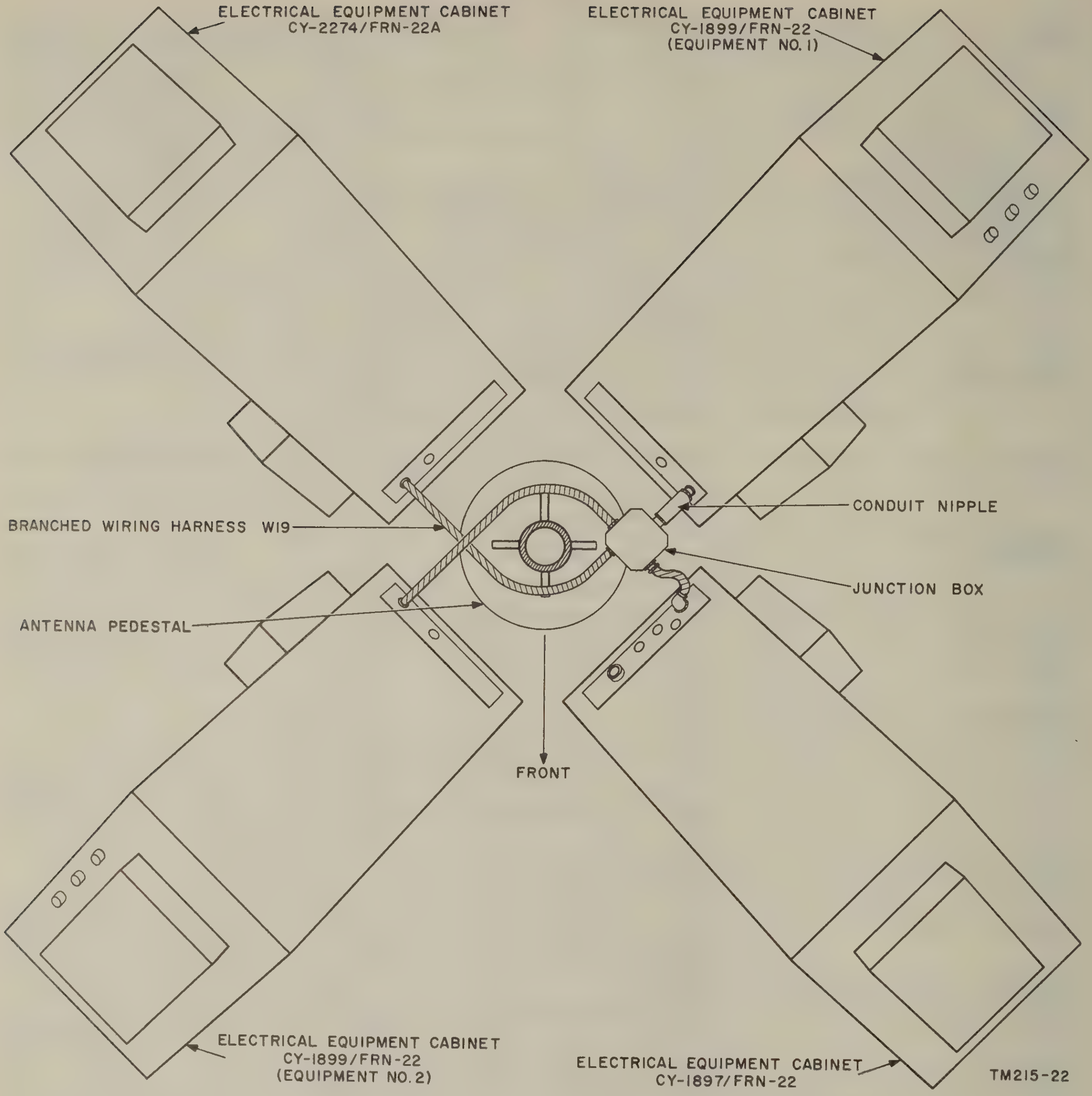


Figure 14. Branched wiring harness W19, installation diagram.

Remove the locknut from the connector on the free end of the conduit. Insert the eight wires and the threaded portion of the conduit connector through the hole adjacent to the porcelain bushing on the lower-left side of the CY–1897/FRN–22. Replace and tighten the locknut.

d. A ¾-inch flexible conduit containing three #10 AWG wires extends from the lower left-rear corner behind the circuit breaker box. Remove the locknut from the connector on the free end of the conduit. Insert the three wires and the threaded portion of the conduit connector through the upper hole in lower-left side of the CY–1897/FRN–22. Replace and tighten the locknut.

16. Installation of Equipment at Remote Control Point

Installation of equipment (fig. 4, TM 11–5825–205–12) at the remote control point consists of assembling the microphone, mounting the handset bracket on the side of the remote control cabinet,

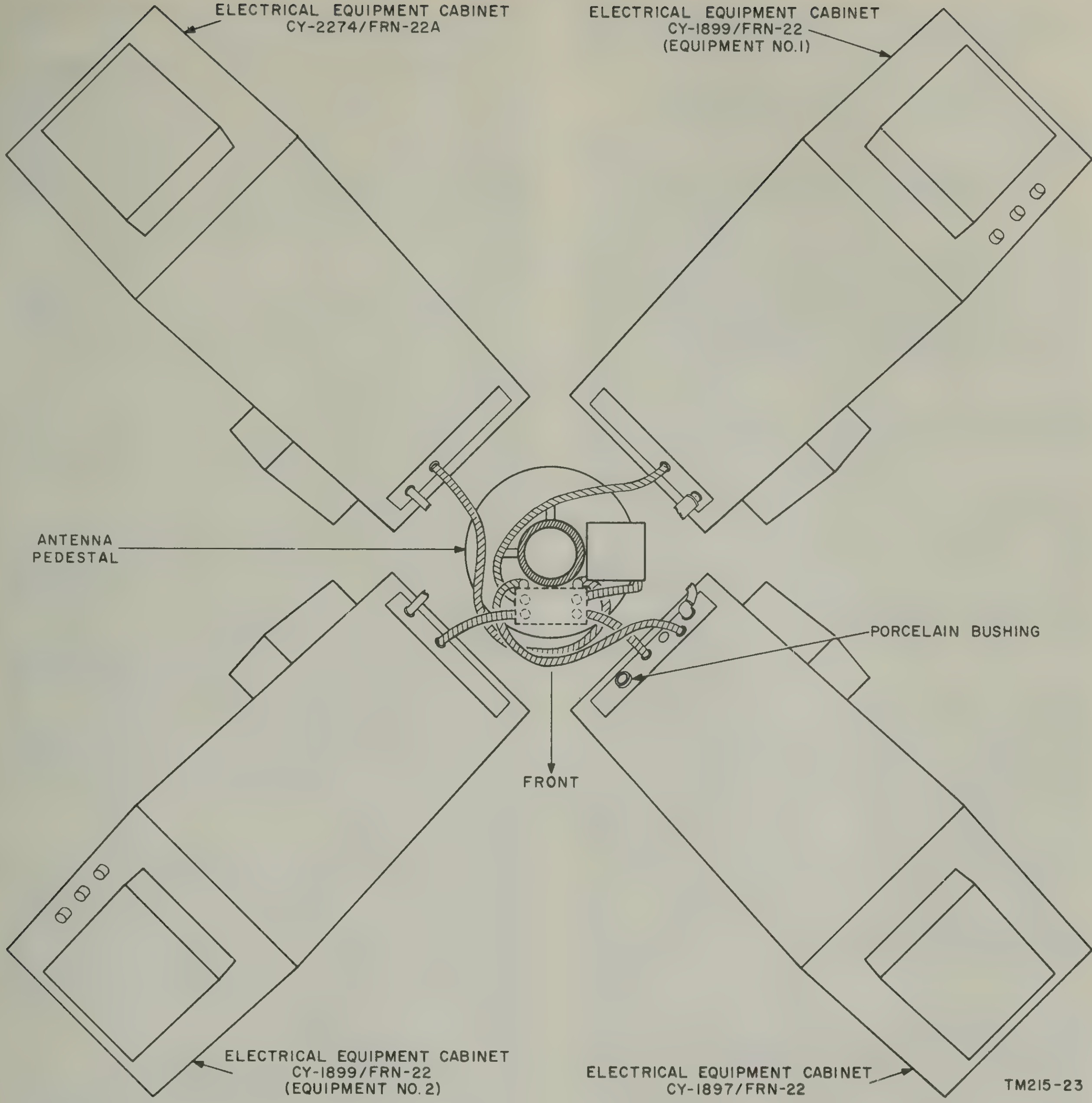

ELECTRICAL EQUIPMENT CABINET CY-2274/FRN-22A
ELECTRICAL EQUIPMENT CABINET CY-1899/FRN-22 (EQUIPMENT NO.1)
ANTENNA PEDESTAL
PORCELAIN BUSHING
FRONT
ELECTRICAL EQUIPMENT CABINET CY-1899/FRN-22 (EQUIPMENT NO. 2)
ELECTRICAL EQUIPMENT CABINET CY-1897/FRN-22
TM215-23

Figure 15. Flexible power conduit, installation diagram.

and selecting the location for the remote control cabinet. Directions for connecting the equipment will be given later. Perform the operations outlined below.

a. Plug the connector on the microphone head into the receptacle on the microphone stand. Tighten the knurled coupling ring securely.

b. A handset mounting bracket is fastened on the interior of the right side of the remote control cabinet. Remove the hardware and bracket. Use the same holes and hardware and fasten the bracket to the outside of the cabinet as shown in figure 13.

c. Several factors should be considered when selecting the best location for the equipment at the remote point. Set the remote control cabinet at the location which best meets the following requirements:

(1) Convenience for the operator.
(2) Accessibility to a 115-volt alternating current (ac) power outlet.
(3) Accessibility to the telephone control

line which is to be run between the remote control point and the site of the omnirange set.

(4) Accessibility to an earth ground.

17. Entry of Lines and Cables into Electrical Equipment Shelter S–120/FRN–22

The lines and cables which must be brought into the shelter are the main powerline for the omnirange equipment, the telephone control line between the remote control point and the shelter, and the radiofrequency (RF) cable and power cable for the AN/FRA–14. The main powerline and the telephone control line (wire pair) are not furnished as part of the omnirange set. Local conditions and preferences of responsible authorities will govern selection of materials used for these lines, based on the following considerations: the main power source must be 195 to 255 volts ac, 50 to 60 cycles per second (cps), single phase, grounded or ungrounded neutral, and the powerline must be able to carry the maximum current (25.5 amperes) with an adequate safety factor. Perform the operations outlined below.

Caution: **Although uncommon, a situation may be encountered where one side of the main ac powerline is at ground potential. Where this condition exists, a line isolation transformer must be used. The current-carrying capacity of the transformer should be the same as that stated above for the powerline.**

a. Run the powerline from the main power source and the control line from the remote control point; bring them together at a point just outside the shelter. *To avoid any chance of affecting the antenna radiation pattern, do not string these lines above ground level any closer than 750 feet from the shelter.* Normally, unless they must cross runways, taxiways, or aircraft ramps, the powerline and control line may be run on the surface of the ground for the remainder of the distance to the shelter. In places where these lines must cross runways, taxiways, or aircraft ramps, bury them. Where the powerline and control line approach the shelter from the same direction, keep the lines at least 2 feet apart all the way to the shelter. Bring the powerline and control line together at either of the two skid sides which does not have runners beneath it. Measure out an additional 15 feet of each line and cut the lines from the spool. Leave the ends of the lines where they are until the cables from the AN/FRA–14 are brought up.

b. Rf cable assembly W7 and power cable assembly W10 each must have one end connected to the AN/FRA–14 before their opposite ends can be brought into the shelter. Connect one end of cable W7 and the end of cable W10, which terminates in a plug, to the AN/FRA–14 as shown in figure 16. Tighten the coupling rings securely.

c. Use plastic clamps or other nonmetallic binding material and fasten cables W7 and W10 to the mounting post at several points. Be sure to leave some slack in the cables.

d. Bring the ends of cables W7 and W10 up to the same point on the side of the skid where the ends of the powerline and control line are located. Use cord or wire and tie the ends of the two lines and two cables tightly together.

e. To permit entry of the lines and cables into the shelter, a 4-inch diameter access hole has already been cut in the plywood top of the skid (par. 7 and fig. 10). Obtain a 10-foot length of #16 AWG solid wire or other strong flexible material to be used as a guide wire to draw the lines and cables into the shelter. From inside the shelter, run one end of the guide wire down through the access hole and out under the skid to the point where the tied ends of the lines and cables are located.

f. Fasten the guide wire securely to the tied ends of the lines and cables. Pull the guide wire back through the access hole until the ends of the lines and cables can be reached through the access hole. Pull the lines and cables into the shelter and coil them out of the way at the base of the antenna pedestal.

18. Cabling and Connections

All interunit cabling and connections are shown on the cording diagram (fig. 16). Connect the equipment within the shelter first, then connect the equipment at the remote control point. Refer to the cording diagram and make the connections as instructed in paragraphs 19 through 25.

19. Equipment Cabinet Connections

(fig. 16, contained in separate envelope)

a. Electrical Equipment Cabinet CY–2274/FRN–22A.

(1) Connect the plugs on the cabinet wiring to the receptacles on the components in the cabinet.

(2) Connect the cabinet wiring to terminal board TB1901 on the meter panel.

(3) Install the plate caps on tubes V4 and V5 in the No. 1 and No. 2 AM–1246/FRN–20.

(4) Connect wires from branched wiring harness W19 to cabinet terminal boards TB1903 through TB1908 and standoff terminals E1901, E1902, E1905, and E1906. Use the extra clamp attached to the terminal board mounting plate and fasten the upper portion of W19 to the mounting plate.

(5) Three #14 AWG wires emerge from the flexible power conduit into the cabinet. Cut these wires to the proper length, strip back the insulation, and connect them to the cabinet ground screw and terminal board TB1909.

b. No. 1 Electrical Equipment Cabinet CY–1899/FRN–22.

(1) Connect the plugs on the cabinet wiring to the receptacles on the components.

(2) Connect RF cables W13, W14, and W15 between the components and between the top of the cabinet and components.

(3) Connect the cabinet wiring to terminal board TB1 and standoff terminal E1 on the PP–1331/FRN–20.

(4) Connect the wires from branched wiring harness W19 to cabinet terminal boards TB1801 and TB1802 and standoff terminals E1801 and E1802.

(5) Two blue wires with plate caps on the ends emerge from the rear of Power Supply PP–1329/FRN–20. Connect the caps to cabinet standoff insulators E1801 and E1802.

(6) Six #14 AWG wires emerge from the flexible power conduit in the cabinet. Only five of these wires are used. Cut the five wires to the proper length, strip back the insulation, and connect them to the cabinet ground and terminal board TB1803.

c. No. 2 Electrical Equipment Cabinet CY–1899/FRN–22. Use the procedure outlined in *b* above. The RF cables are W16, W17, and W18.

d. Electrical Equipment Cabinet CY–1897/FRN–22.

(1) Connect the plugs on the cabinet wiring to the receptacles on the components.

(2) Connect power cables W6, W8, W9, W11, and W12 between the cabinet ac outlet strip and the components.

(3) Connect the cabinet wiring to terminal board E201 on the C–1738/FRN–20.

(4) Connect the cabinet wiring to terminal board TB501 on the No. 1 and No. 2 keyers.

(5) Connect the cabinet wiring to terminal board TB1202 on the PP–1415/FRN–22.

(6) Connect jumper wire W23 between terminal 4 of cabinet terminal board TB801 and terminal 9 of cabinet terminal board TB802.

(7) Connect the wires from branched wiring harness W19 to cabinet terminal boards TB801 through TB804.

(8) Eight #14 AWG wires emerge from one of the flexible power conduits in the cabinet. Cut the wires to the proper length, strip back the insulation, and connect them to the cabinet ground and terminal boards TB801, TB802, and TB805.

(9) Three #14 AWG wires emerge from one of the flexible power conduits in the cabinet. Cut the wires to the proper length, strip back the insulation, and connect them to terminal board TB1 at the rear of the voltage regulator.

(10) Insert handset HS2 plug into the MONOPHONE receptacle on the front panel of the C–1738/FRN–20. Hang the handset on the bracket on the right side of the cabinet.

20. Connection of Telephone Control Line and Antenna Group AN/FRA–14 Cables

(fig. 16, contained in separate envelope)

a. Uncoil the two lines and two cables which enter the shelter through the access hole in the skid and untie the ends.

b. Coil the main powerline and leave it at the base of the antenna pedestal. Insert the ends of the telephone control line and cables W7 and W10 through the porcelain bushing in the lower-right side of the CY–1897/FRN–22.

c. Run RF cable W7 straight up against the side of the cabinet and behind the power cables and cabinet wiring already connected to the components. Connect the W7 cable plug to receptacle J1 on the monitor.

d. Run power cable W10 against the side of the cabinet in the same manner as cable W7 (*c* above). Cable W10 is to be terminated in plug P401 which will be found inserted in receptacle J405 on RE–247/FRN–22. Cut cable W10 so that it will reach receptacle J405 and still have several inches of slack.

e. Remove plug P401 from receptacle J405. Strip back the insulation from the ends of the cable wires and attach plug P401 to the cable. Insert plug P401 into receptacle J405.

f. Cut the telephone control line to the proper length to reach terminals 1 and 2 of cabinet terminal board TB804 and still have several inches of slack. Strip back the insulation from the ends of the wires and connect them to terminals 1 and 2 of TB804.

21. Connection of RF Cables to Antenna Relay Assembly

(fig. 16, contained in separate envelope)

a. Three RF cables from the antenna emerge from the access hole at the rear of the antenna pedestal. Connect 14-inch RF cable W5 to the end of the antenna RF cable which terminates in a plug that is not marked with a color.

b. Connect the three RF cables to receptacles J1004, J1007, and J1010 on the antenna relay assembly mounted on the antenna pedestal.

c. Connect 60-inch RF cables W13, W14, and W15 from receptacles J1801, J1802, and J1803 on the No. 1 CY–1899/FRN–22 to receptacle J1005, J1008, and J1011 respectively, on the antenna relay assembly. To remove the weight of the cables from the bends at the termination points, clamp or lash the three cables to the nearest roof stiffener.

d. Connect 60-inch RF cables W16, W17, and W18 from receptacles J1801, J1802, and J1803 on the No. 2 CY–1899/FRN–22 to receptacles J1003, J1006, and J1009 respectively, on the antenna relay assembly. To remove the weight of the cables from the bends at the termination points, clamp or lash the three cables to the nearest roof stiffener.

22. Ground Connection

(fig. 16, contained in separate envelope)

A #10 AWG wire emerges from the porcelain bushing at the bottom of the convenience outlet box mounted on the antenna pedestal. A ground rod clamp is attached to this wire. Cut the wire to the proper length to reach the ground rod which was driven through the access hole in the skid. Strip back the insulation on the wire. Insert the wire between the ground rod and the ground rod clamp, and tighten the clamp bolt securely.

23. Antenna Heater and Aircraft Obstruction Marker Light MX–1919/FRN–22 Cable Connection

(fig. 16, contained in separate envelope)

a. The antenna heater and obstruction light cables emerge from the access hole at the rear of the antenna pedestal. The two cables are to be connected inside the lower circuit breaker box through the box connectors shown in figure 3 of TM 11–5825–205–12. Remove the front cover of the lower circuit breaker box.

b. Bring the rubber covered antenna heater cable around the pedestal to the box connector on the right of the circuit breaker box as viewed from the front. Strip back the outer cover of the cable far enough to permit the lugs on the two cable wires to reach the correct terminals inside the circuit breaker box.

c. Loosen the clamp on the box connector. Taper the outer covering of the cable with a sharp knife or razor blade until it will fit through the connector.

d. Insert the two cable wires and tapered end of the cable through the connector. Tighten the connector clamp.

e. Connect the cable wires.

f. Bring the shield-braid covered obstruction light cable around the pedestal to the box connector on the left of the circuit breaker box as viewed from the front. Loosen the clamp on the box connector and insert the cable through the connector.

g. Connect the cable wires. Tighten the cable clamp.

h. Replace the front cover on the circuit breaker box.

24. Propeller Ventilating Fan HD–244/FRN–22 and Main Powerline Connections

(fig. 16, contained in separate envelope)

a. Both the shelter blower and the main powerline connect inside the upper circuit breaker box on the antenna pedestal. Remove the front cover of the upper circuit breaker box.

b. The 90° connector on the end of the flexible conduit from the shelter blower fastens through a ¾-inch knockout on the lower right side of the circuit breaker box as viewed from the front (fig. 8). Use a hammer and punch to remove the knockout.

c. Remove the locknut from the 90° connector. Insert the threaded portion of the connector and the ends of the inclosed wires through the knockout in the circuit breaker box. Replace the locknut on the connector and tighten it securely.

d. Cut the wires to the proper length to reach the correct terminals inside the circuit breaker box. Strip the insulation from the ends of the wires and connect them to the proper terminals.

e. Run the main powerline cable through a flexible conduit from the access hole in the skid to the upper circuit breaker box on the antenna pedestal. Entry to the circuit breaker box should be made through a 90° connector. Because of variations in sizes and types of powerlines used, the flexible conduit and connector are not supplied as a part of the omnirange set. Use a hammer and punch to remove the knockout on the lower-left side of the circuit breaker box. Be sure the knockout removed is of the proper size to clear the 90° connector.

f. Insert the powerline wires through the flexible conduit of the proper length. Feed the wires through the connector and fasten the connector to the end of the conduit.

g. Remove the locknut from the connector. Insert the threaded portion of the connector and ends of the powerline wires through the knockout in the circuit breaker box. Replace the locknut on the connector and tighten it securely.

h. Cut the powerline wires to the proper length to reach the correct terminals inside the circuit breaker box. Strip the insulation from the ends of the wires and connect the wires to the proper terminals.

i. Replace the front cover on the circuit breaker box.

25. Connections at Remote Control Point

(fig. 16, contained in separate envelope)

a. Open the lid of the CY–1826/FRN–20. Bring the telephone control line inside the cabinet through the opening at the rear.

b. Cut off the ends of the control line to the proper length, strip back insulation, and connect the wires to terminals 1 and 2 of E501.

c. Connect a wire from earth ground to terminal 10 of terminal board E501.

d. Connect power cable W22 to the receptacles on the remote control unit and AM–1247/FRN–20. Do not connect power cable W22 to an ac outlet at this time.

e. Close the lid on the remote control cabinet.

f. Connect handset plug HS1 to the MONOPHONE receptacle. Connect microphone MK1 plug to the MICROPHONE receptacle.

26. Cable and Wiring Check

After installation and before applying power to the equipment, check as follows to see that the omnirange set has been properly cabled for operation.

a. See that all cables are installed and connected to the proper receptacles on each component according to the cording diagram (fig. 16, contained in separate envelope).

b. Be sure that all cables, especially the RF cables, are free from sharp bends and are placed to prevent contact with surfaces which may cut or damage the insulation.

c. At each component, see that all plugs and receptacles mate properly and that all plug coupling rings are tightened securely.

d. Be sure that all wires from two-conductor cables, wiring harnesses, and flexible conduit make correct entrance to the connection points and are securely connected to the proper terminal board terminals according to color coding shown in the cording diagram (fig. 16, contained in separate envelope).

e. Connections at the remote control point between the remote control unit and the AM–1247/FRN–20 have been made at the factory and are shown in the cording diagram (fig. 16, contained in separate envelope). Check these connections against the following table:

Cable No.	Connection points	
	Radio Set Control C–1739/FRN–20	Audio Frequency Amplifier AM–1247/FRN–20
W20	Terminals 3 and 4 of E501	J1.
W21	Black wire to terminal 10 of E591. Remaining two wires to terminals 5 and 6 of E501.	J2.

27. Installation of Tubes and Thermal Relays

With the exception of the large glass-envelope tubes and a single tube-type thermal relay, the components are shipped with tubes and thermal relays installed. The thermal relay and tubes that are not already installed are shipped in the container with the component to which they belong. Directions for the temporary safekeeping of these tubes and relay until they can be installed are given in paragraph 3. Except for the AM–1247/FRN–20 and AN/FRA–14, all components which require tubes are located inside the shelter (fig. 2, TM 11–5825–205–12). The AM–1247/FRN–20 is located at the remote control point. The AN/FRA–14 is mounted on a post approximately 100 feet from the shelter. The components which require thermal relays are also located within the shelter. Install or check the installation of tubes and thermal relays as follows:

a. The locations of tubes in the goniometer are shown in figure 17. Check both goniometers to see that all tubes are firmly in place and covered by tube shields.

b. Locations of tubes in the modulation eliminator are shown in figure 18. On both modulation eliminators, remove the shield cover which incloses V1. Be sure that V1 is firmly in place and the plate cap installed. Replace the shield cover. See that V3 is firmly in place and covered by a tube shield. Install V2 and V4.

c. Locations of tubes in the transmitter are shown in figure 19. Install V7 and V8 and place

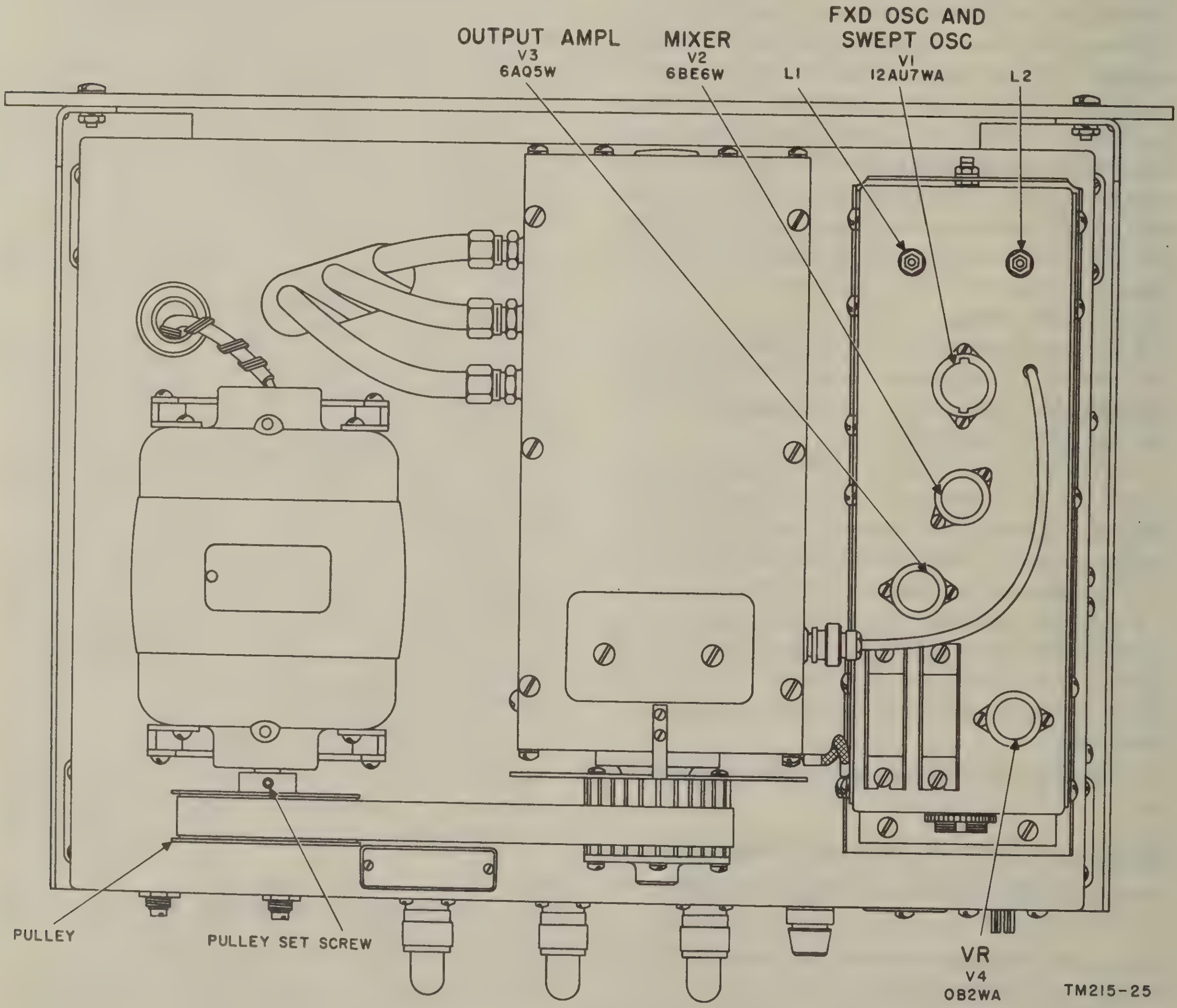


Figure 17. Electrical Goniometer GO–12/FRN–20, tube and control locations.

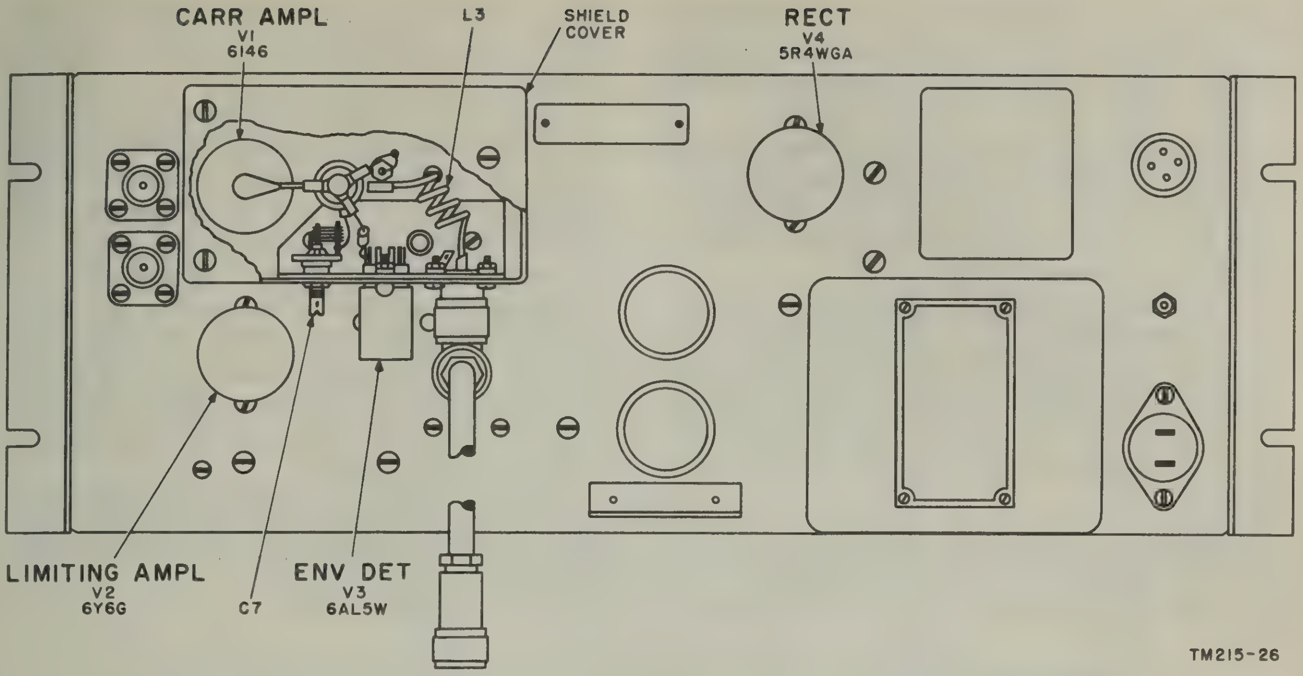


Figure 18. Modulation Eliminator MX–1843/FRN–20, tube and control locations.

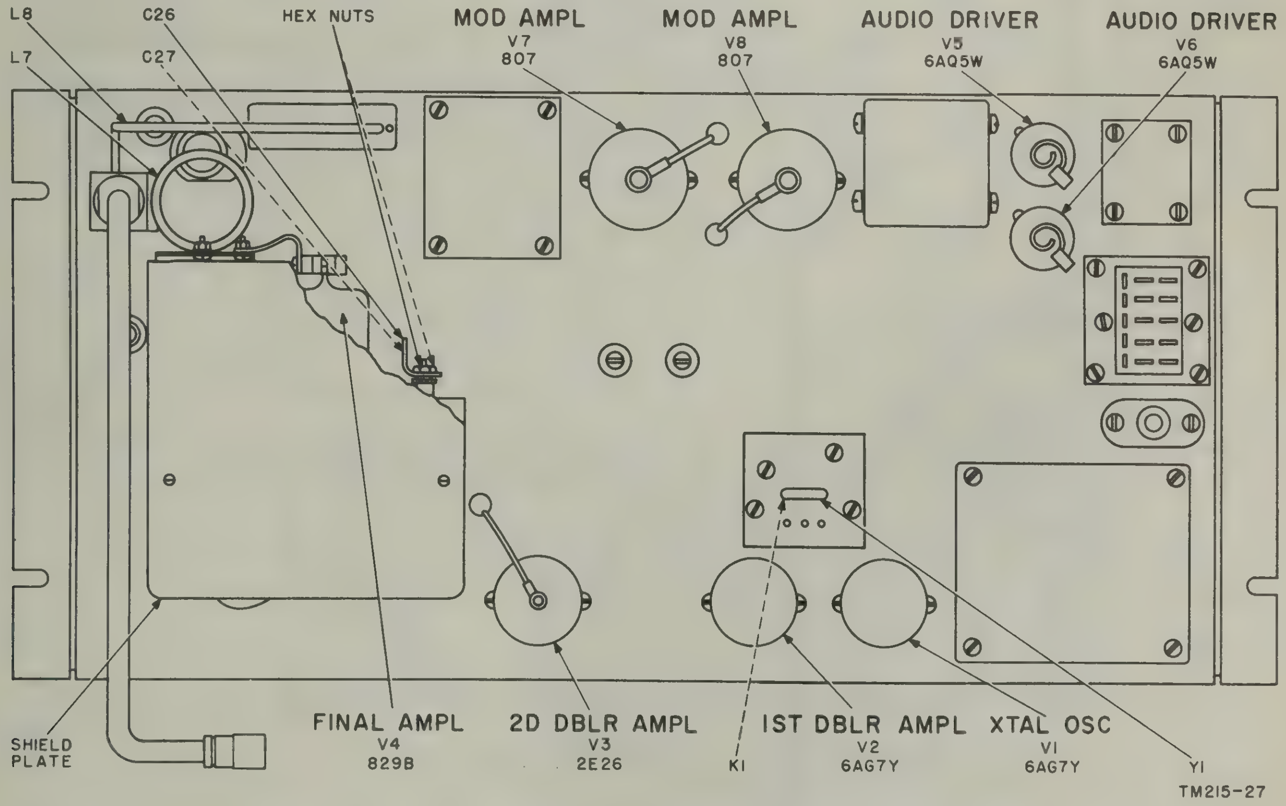


Figure 19. Radio Transmitter T–573/FRN–20, tube and crystal locations.

a tube cap on each tube in both transmitters. See that all other tubes are firmly in place, that there are caps on V3 and V4, and that V5 and V6 are held in place by spring retainers.

d. Locations of tubes and the thermal relay in the PP–1331/FRN–20 are shown in figure 20. Install V1, V2, V3, and V4 in both units. Place caps on V1 and V2. See that thermal relay S3 is firmly in place.

e. Locations of tubes and the thermal relay in the PP–1329/FRN–20 are shown in figure 21. Install V1401, V1402, V1403, and thermal relay S1401 in both units. Plate caps are located on the ends of the two yellow high-voltage leads. Place one plate cap on V1401 and the other on V1402.

f. Locations of tubes and the thermal relay in the O–371/FRN–20 are shown in figure 22. Install tube V904 in both units. See that all other tubes are firmly in place and covered by tube shields. See that thermal relay K902 is firmly in place.

g. Locations of tubes in the AM–1246/FRN–20 are shown in figure 23. Install V1, V2, V3, V4, and V5 in both units. Lock the tube clamps around the bases of V4 and V5. Place the plate caps with brown leads (E1801 and E1802 in the CY–1899/FRN–22, fig. 16) on V4 and V5.

h. Locations of tubes in the monitor are shown in figure 24. Install V10. See that all other tubes are firmly in place, that all tubes except V10, V20, V21, and V22 are covered by tube shields, and that V20, V21, and V22 are held in place by spring retainers.

i. Locations of tubes and the fuse in the O–373/FRN are shown in figure 25. On both O–373/FRN oscillators, install V3. See that V1, V2, and F1 are firmly in place.

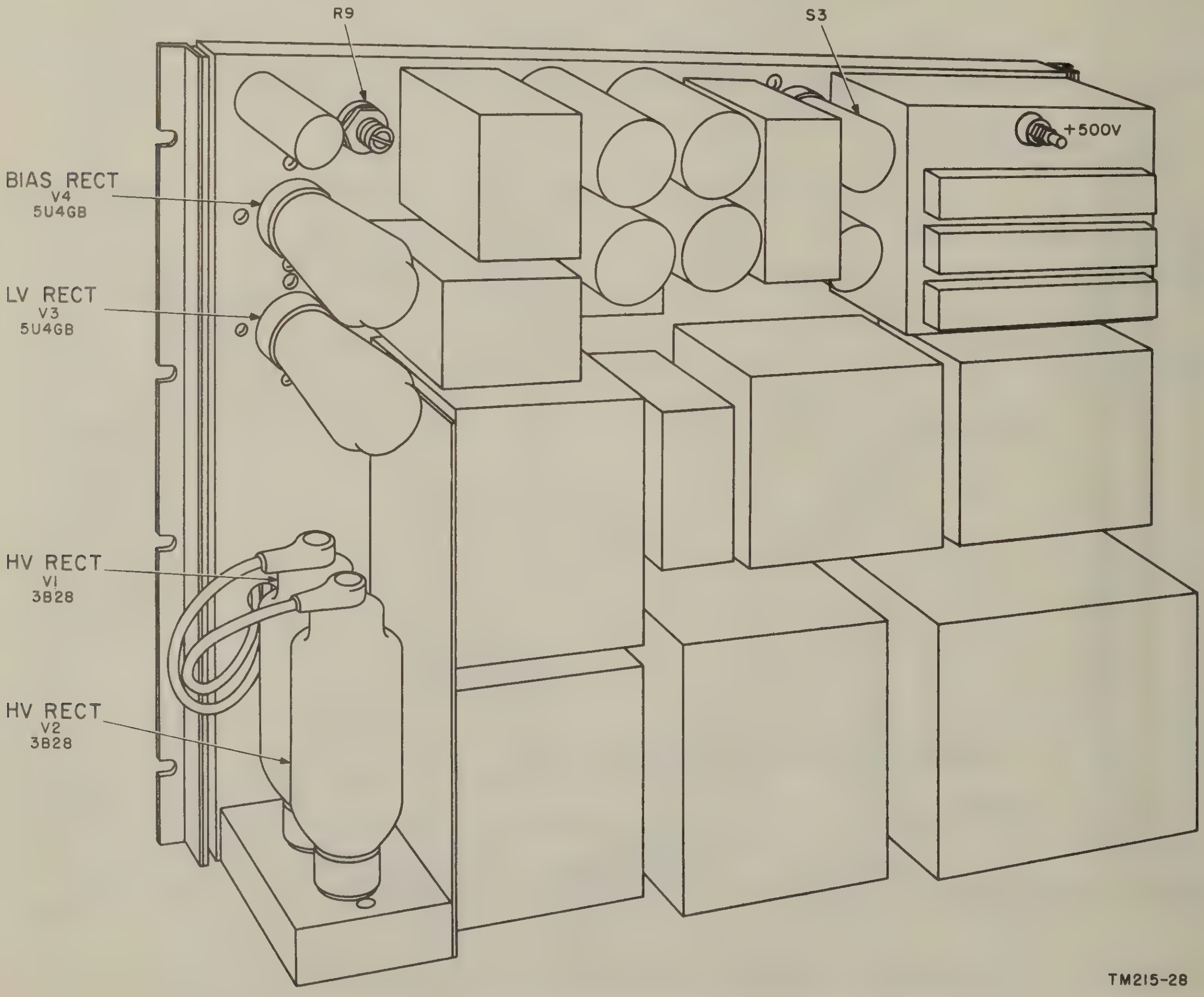


Figure 20. Power Supply PP–1331/FRN–20, tube, control, and thermal relay locations.

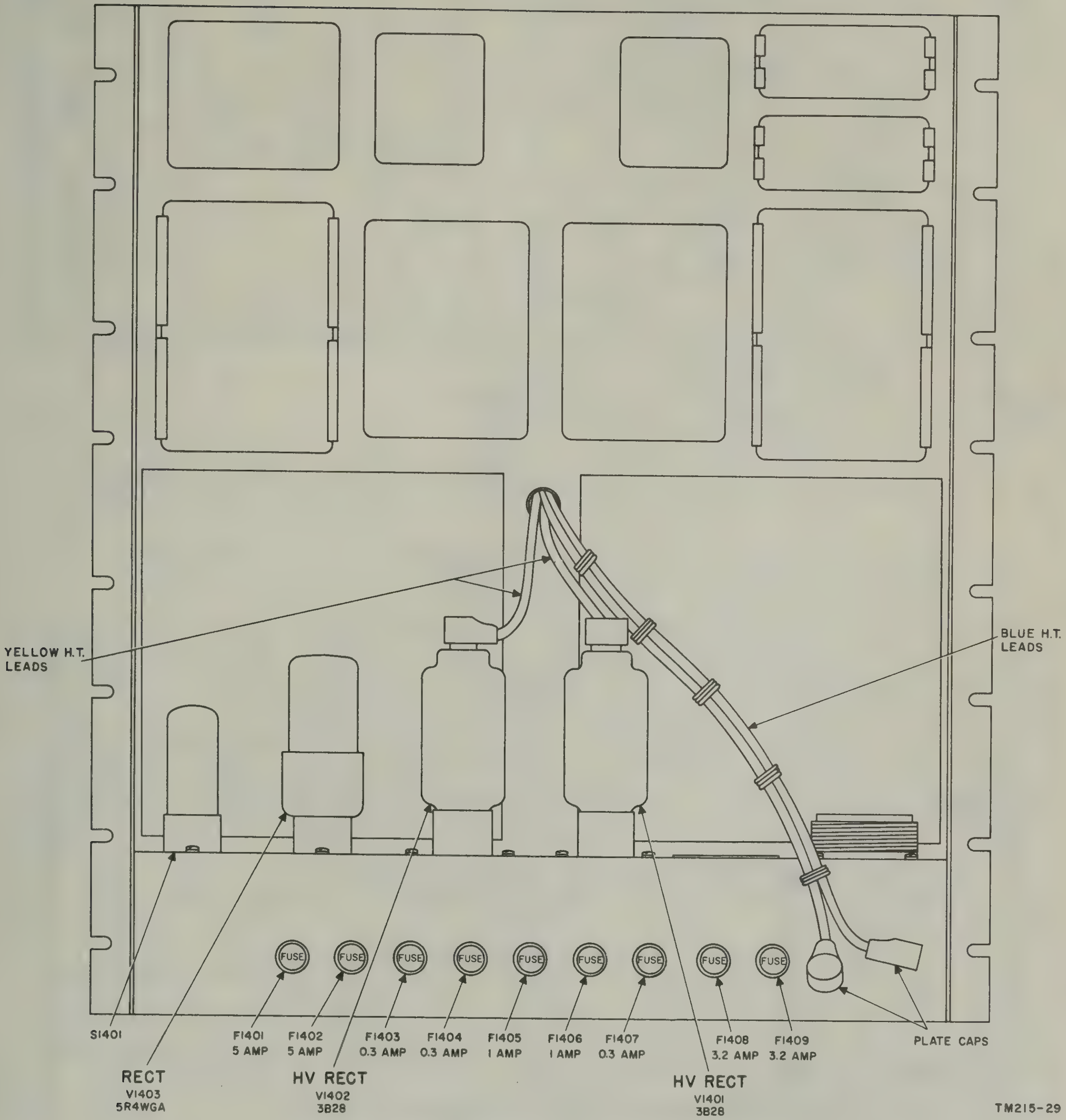


Figure 21. Power Supply PP–1329/FRN–20, tube, fuse, and thermal relay locations.

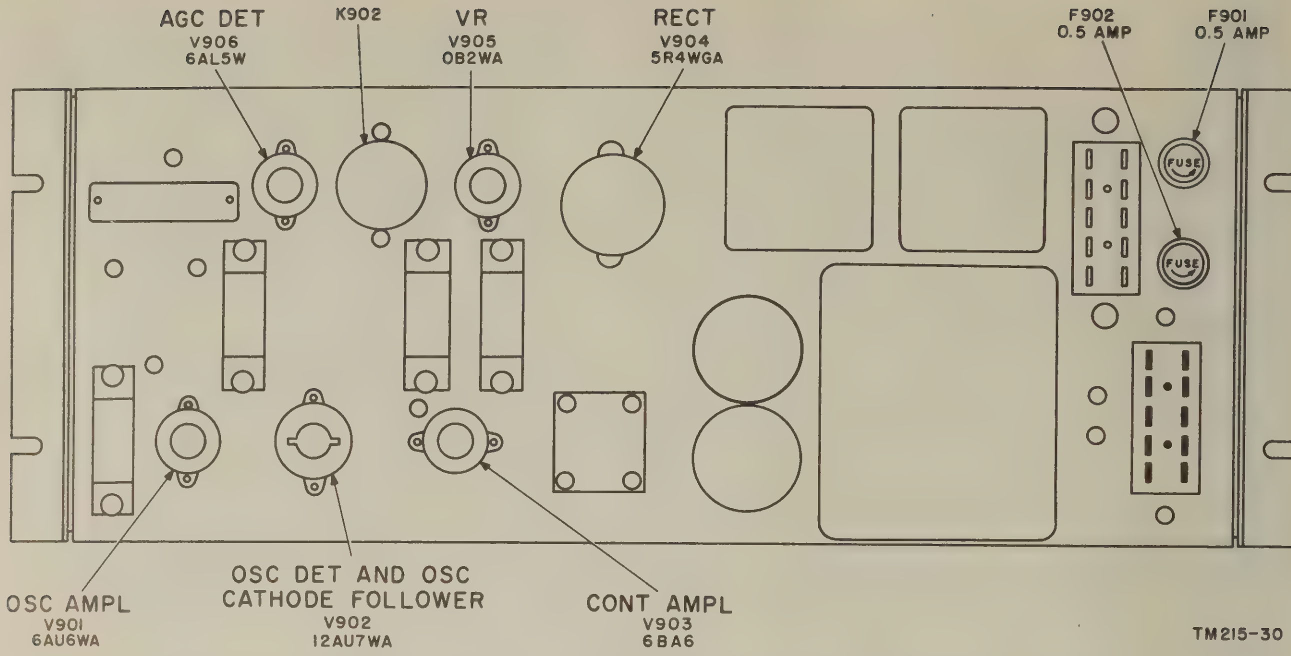


Figure 22. Audio-Frequency Oscillator O-371/FRN-20, tube, fuse, and thermal relay locations.

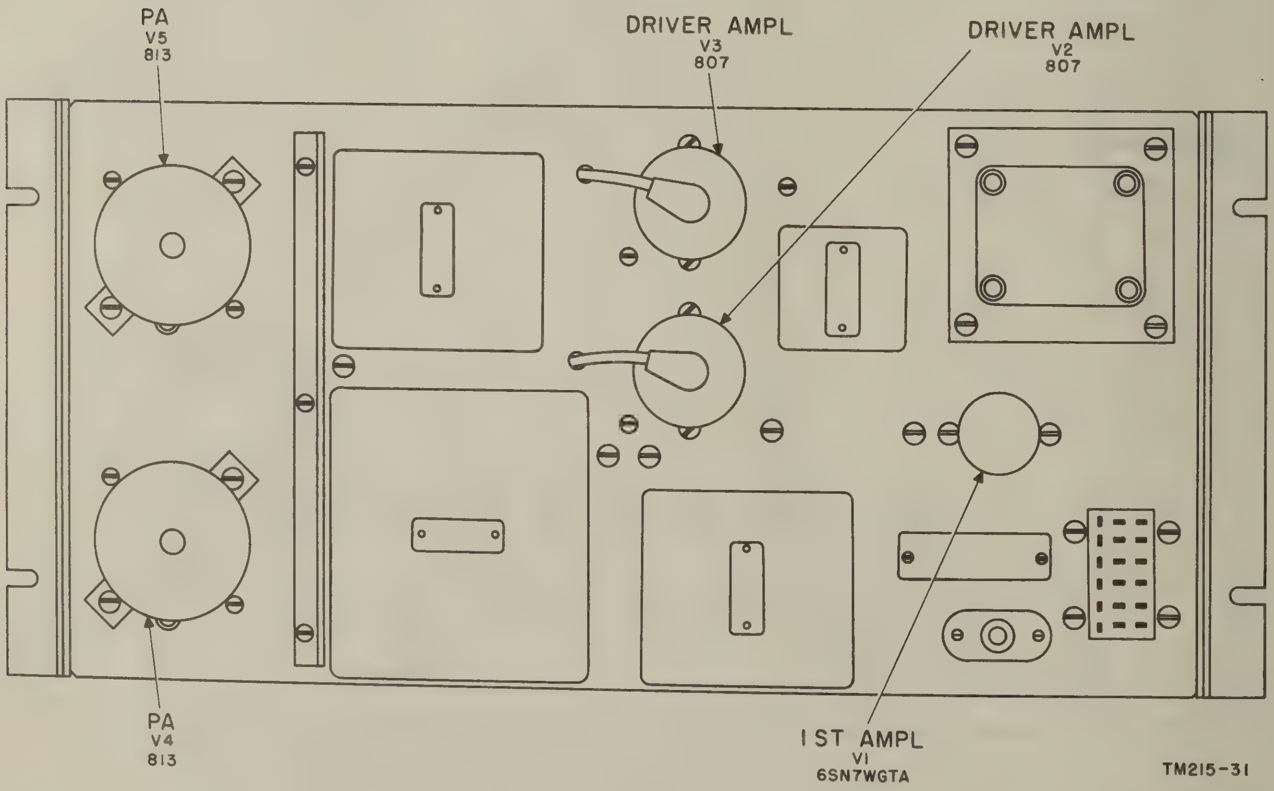


Figure 23. Audio-Frequency Amplifier AM-1246/FRN-20, tube locations.

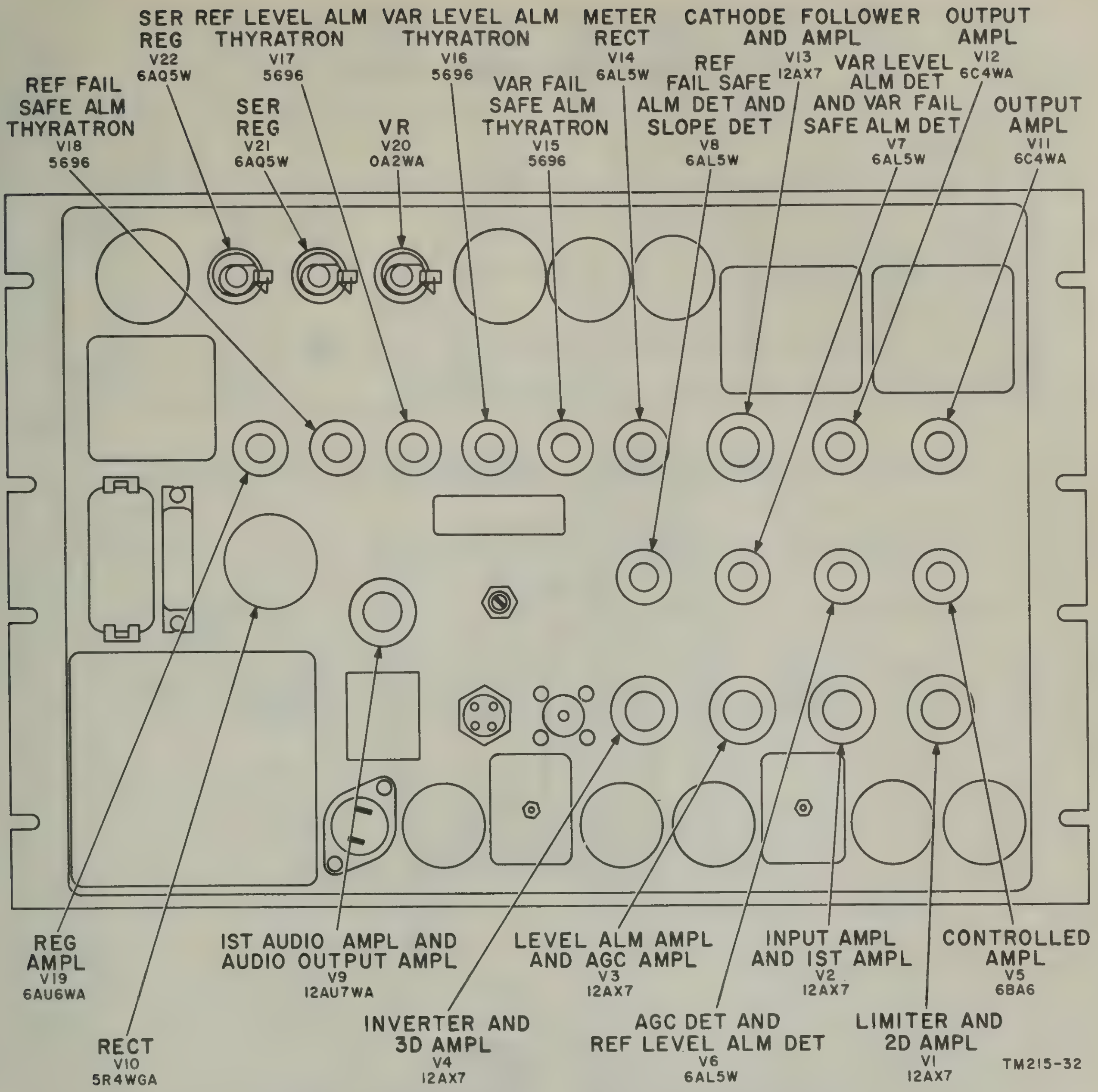

SER REG V22 6AQ5W
REF LEVEL ALM THYRATRON V17 5696
VAR LEVEL ALM THYRATRON V16 5696
METER RECT V14 6AL5W
CATHODE FOLLOWER AND AMPL V13 12AX7
OUTPUT AMPL V12 6C4WA
REF FAIL SAFE ALM THYRATRON V18 5696
SER REG V21 6AQ5W
VR V20 OA2WA
VAR FAIL SAFE ALM THYRATRON V15 5696
REF FAIL SAFE ALM DET AND SLOPE DET V8 6AL5W
VAR LEVEL ALM DET AND VAR FAIL SAFE ALM DET V7 6AL5W
OUTPUT AMPL V11 6C4WA
REG AMPL V19 6AU6WA
RECT V10 5R4WGA
IST AUDIO AMPL AND AUDIO OUTPUT AMPL V9 12AU7WA
INVERTER AND 3D AMPL V4 12AX7
LEVEL ALM AMPL AND AGC AMPL V3 12AX7
AGC DET AND REF LEVEL ALM DET V6 6AL5W
INPUT AMPL AND IST AMPL V2 12AX7
LIMITER AND 2D AMPL V1 12AX7
CONTROLLED AMPL V5 6BA6
TM215-32

Figure 24. Course Monitor MX–1837/FRN–20, tube locations.

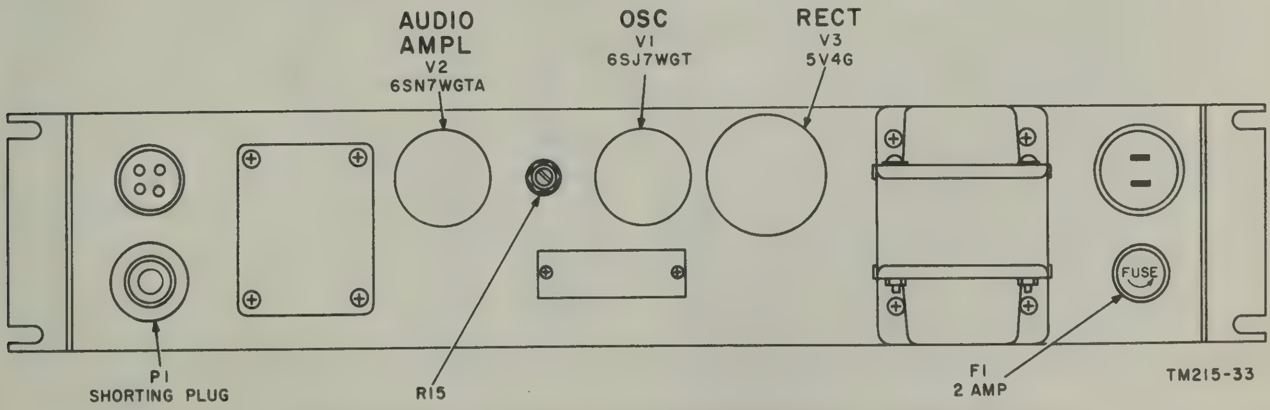


Figure 25. Audio-Frequency Oscillator O–373/FRN, tube, fuse, and control locations.

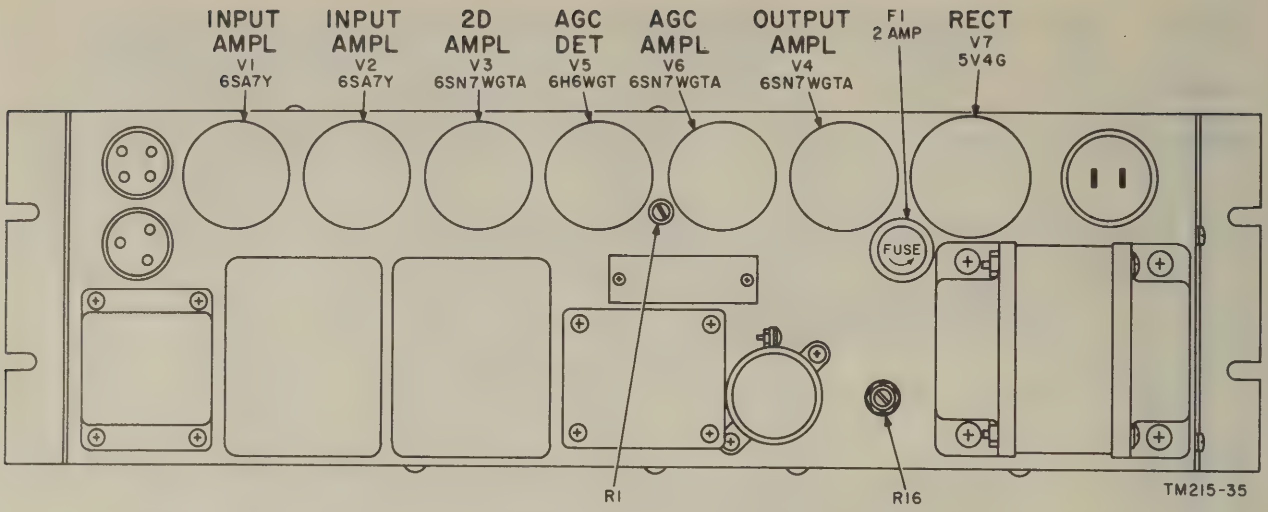


Figure 26. Audio Frequency Amplifier AM–1247/FRN–20, tube, fuse, and control locations.

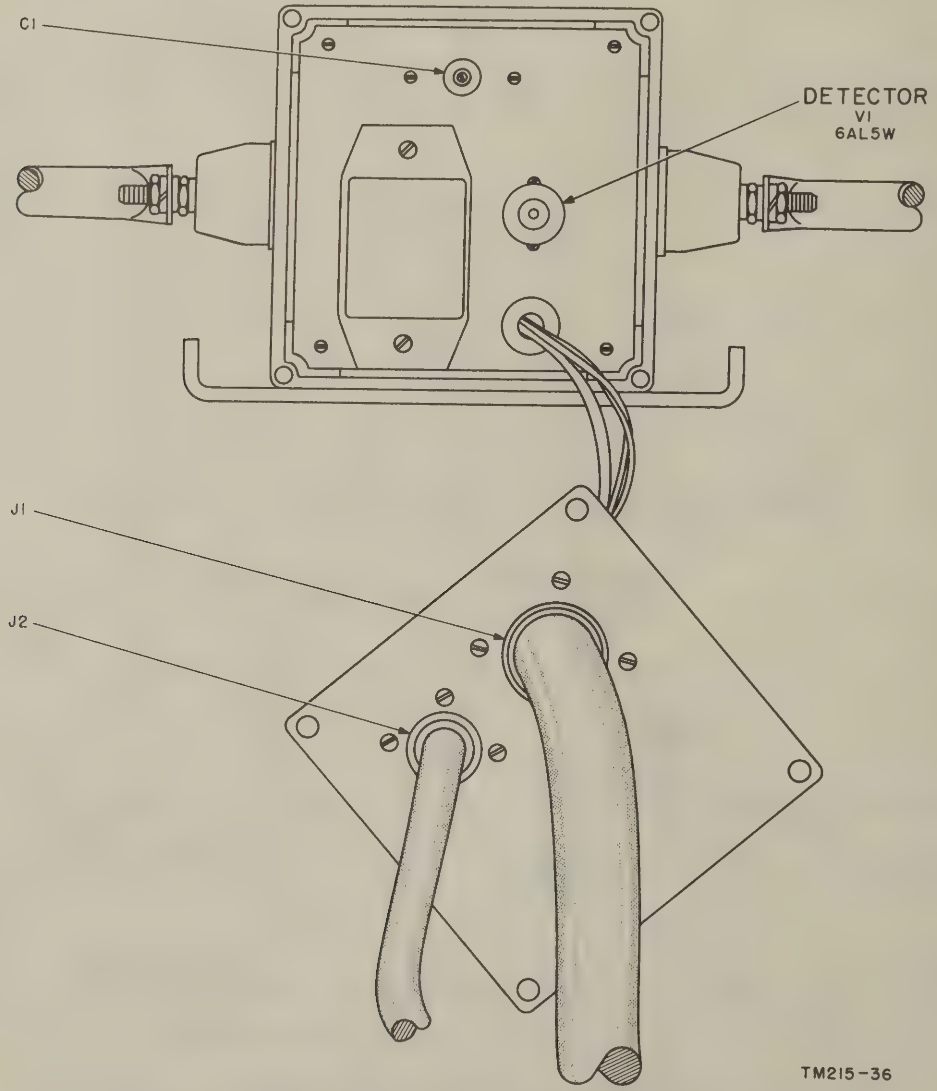


Figure 27. Antenna Group AN/FRA–14, tube and control locations.

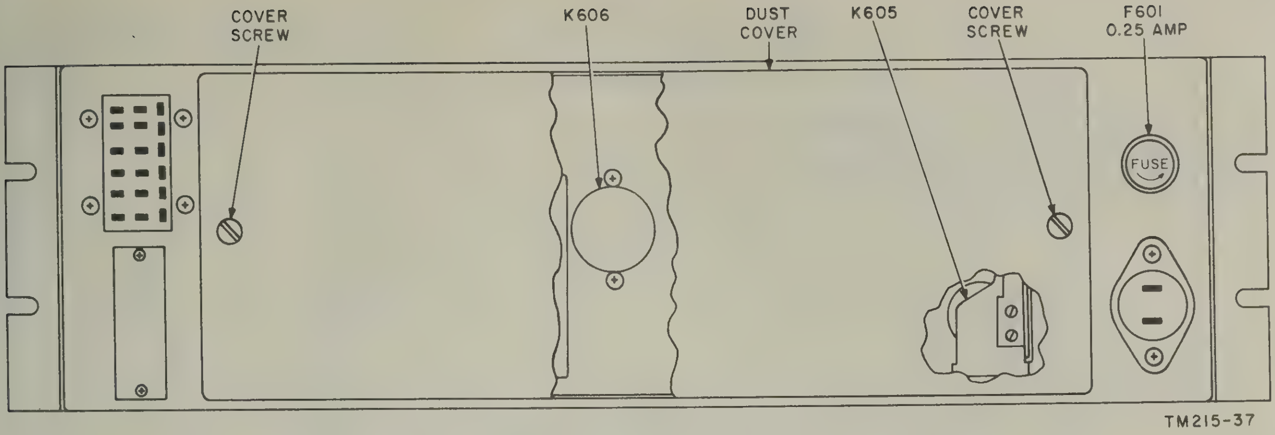


Figure 28. Radio Set Transfer Control C–1840/FRN–22, thermal relay and fuse locations.

j. Locations of tubes and fuses in voltage regulator are shown in figure 269. See that V1, V2, F1, F2, and F3 are firmly in place.

k. Locations of tubes and the fuse in the AM–1247/FRN–20 are shown in figure 26. See that all tubes and the fuse are firmly in place.

l. Location of the single tube, V1, in the AN/FRA–14 is shown in figure 27. Check to see that this tube is firmly in place and covered with a tube shield during the initial adjustments (par. 43).

m. Location of the termal relay and fuse in the C–1840/FRN–22 is shown in figure 28. Remove the two screws that hold the cover in place. Remove the cover and see that thermal relay K606 and F601 are firmly in place. Replace the cover and fasten it in position with the screws.

28. Installation of Crystals and Fuses

Each transmitter is shipped without crystal Y1 installed. Instructions for installation are given in *a* below. All components which require fuses are shipped with the fuses installed. Because equipment failure often results from the use of fuses other than those specified, each fuse holder should be checked to see that it contains the proper fuse. Fuse data necessary to make this check are contained in *b* below.

a. Crystals. Crystal Y1 plugs into crystal socket K1 on the transmitter as shown in figure 19. The frequency of crystal Y1 will be one-fourth of the transmitter frequency used and will always be within the frequency range of 27 to 29.5 megacycles (mc). Install a crystal of the proper frequency in both transmitters and make sure that it is held firmly in place by the retainer spring.

b. Fuses. Check all fuses except the fuse for each equipment cabinet blower. Cabinet blower fuses will be checked during the installation of the blowers (par. 29). The table on following page shows the locations and values of all fuses.

29. Installation of Cabinet Blowers

(fig. 35)

The installation of a blower on each of the four equipment cabinet doors can be done most easily by two men working outside the shelter. Perform the operations outlined below.

a. Have one man hold the door upright while the second man installs the blower. The blower is fastened to the inside of the cabinet door with hardware when shipped from the factory. Remove the blower from the door.

b. A cloth bag containing a cable clamp, an ac plug, and mounting hardware is fastened to the blower cable inside the blower housing. Remove the bag and empty it. From the outside of the cabinet door, insert the end of the blower cable through the rubber grommet in the cabinet door. Fasten the blower to the outside of the door with the No. 8 by ½-inch sheet metal screws and lockwashers provided. Fasten the blower cable to the door with the cable clamp and hardware.

c. Unscrew the two sections of the ac power plug. Slip the top section of the plug over the end of the blower cable. Connect the blower cable wires to the terminals on the bottom section of the plug. Bend the lugs on the cable wires so that the two sections of the plug can mate properly. Screw the two sections of the plug together.

Component	Fuse symbol	Rating (amp)	Reference (fig. No.)
Electrical Equipment Cabinet CY-1899/FRN-22	F1	3	29
Electrical Goniometer GO-12/FRN-20	F1	.8	30
Modulation Eliminator MX-1843/FRN-20	F1	1	31
Power Supply PP-1331/FRN-20	F1	10	242
	F2	10	242
	F3	.5	242
	F4	.5	242
	F5	.75	242
Power Supply PP-1329/FRN-20	F1401	5	21
	F1402	5	21
	F1403	.3	21
	F1404	.3	21
	F1405	1	21
	F1406	1	21
	F1407	.3	21
	F1408	3.2	21
	F1409	3.2	21
	F1410	.5	239
	F1411	.5	239
Electrical Equipment Cabinet CY-2274/FRN-22A	F1	3	29
Audio Frequency Oscillator O-371/FRN-20	F901	.5	22
	F902	.5	22
Electrical Equipment Cabinet CY-1897/FRN-22	F1	3	29
Radio Set Transfer Control C-1840/FRN-22	F601	.25	28
Course Monitor MX-1837/FRN-20	F1	1.5	217
Relay Assembly RE-247/FRN-22	F401	1	263
Audio Frequency Oscillator O-373/FRN	F1	2	25
Keyer Ky-175/FRN	F501	.15	235
Power Supply PP-1415/FRN-22	F1201	2	245
	F1202	5	245
Voltage Regulator CN-358/FRN-22	F1	3	269
	F2	3	269
	F3	3	269
	F4	1	34
	F5	1	34
Propeller Ventilating Fan HD-244/FRN-22	F1001	5	8
Radio Set Control C-1739/FRN-20	F501	1	222
Audio Frequency Amplifier AM-1247/FRN-20	F1	2	210

d. On each cabinet, count the number of interlock receptacles in the upper right-hand corner of the door opening. Find a door with an equal number of mating interlock plugs. Mount the door on the cabinet hinge pins.

e. Insert the plug on the end of each blower cable into the receptacle mounted just inside the cabinet door opening and adjacent to the lower door hinge. Close each cabinet door. Be sure that the interlock plugs and receptacles mate properly and the door is tightly closed.

f. Check the fuse for each cabinet blower to see that it has the correct value (par. 28*b*). The blower fuse for each cabinet is located inside the blower housing (fig. 29). To gain access to the fuse, loosen the four quick-action fasteners which hold the cover on the blower housing and remove the cover and air filter (fig. 29). Replace the filter in the blower housing with the arrows on its side pointing toward the blower. Replace the cover on the blower housing and tighten the fasteners.

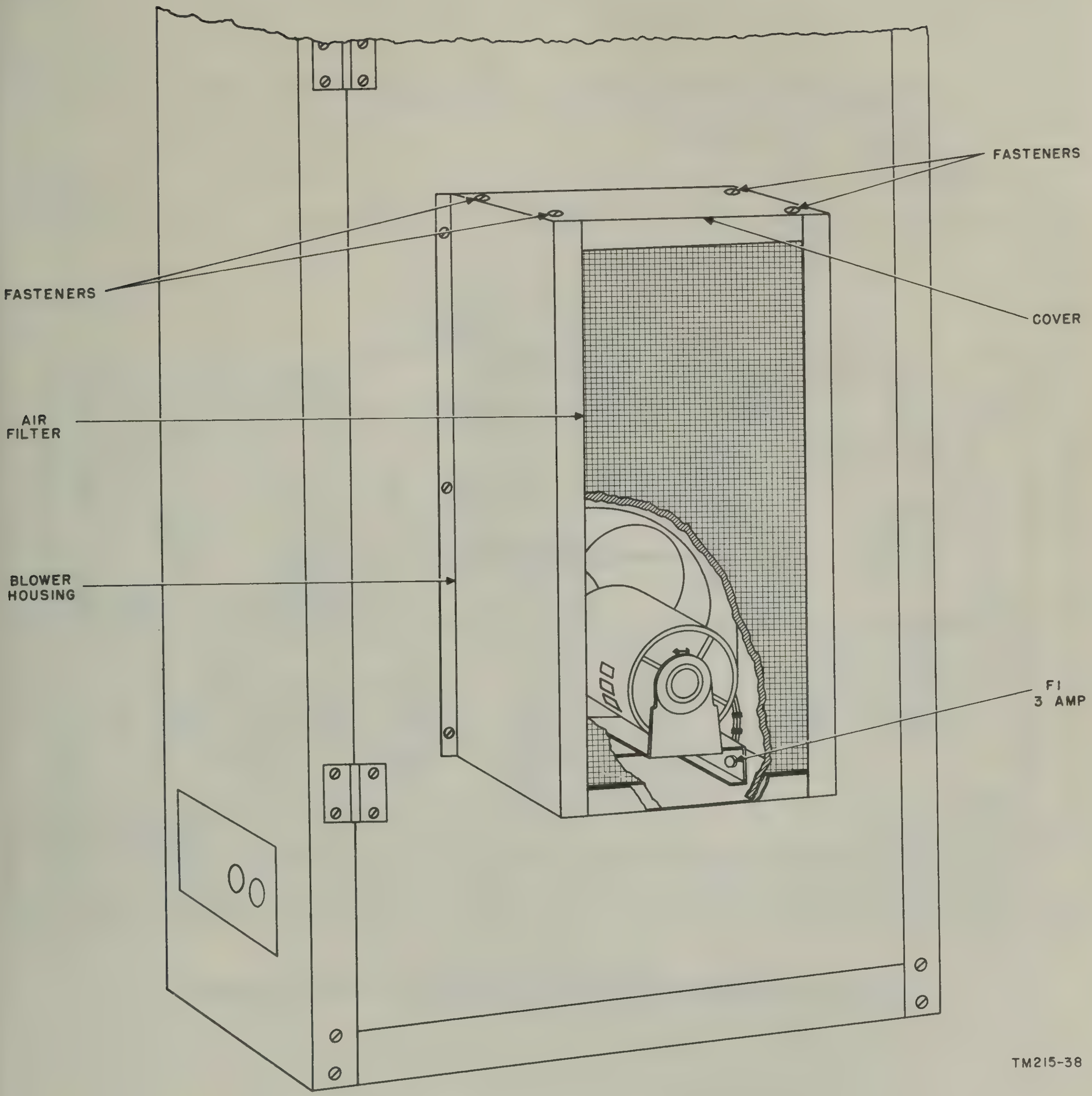
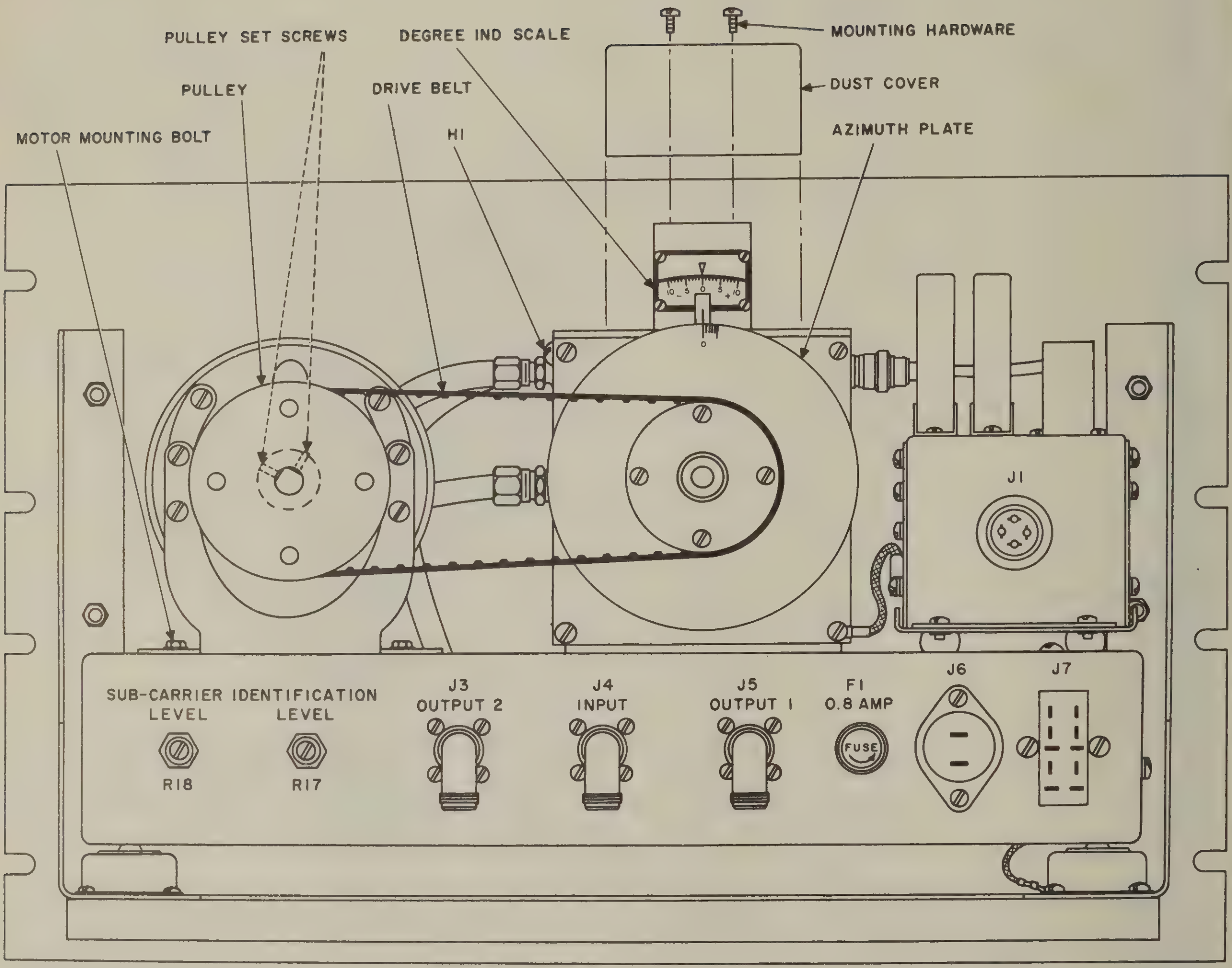


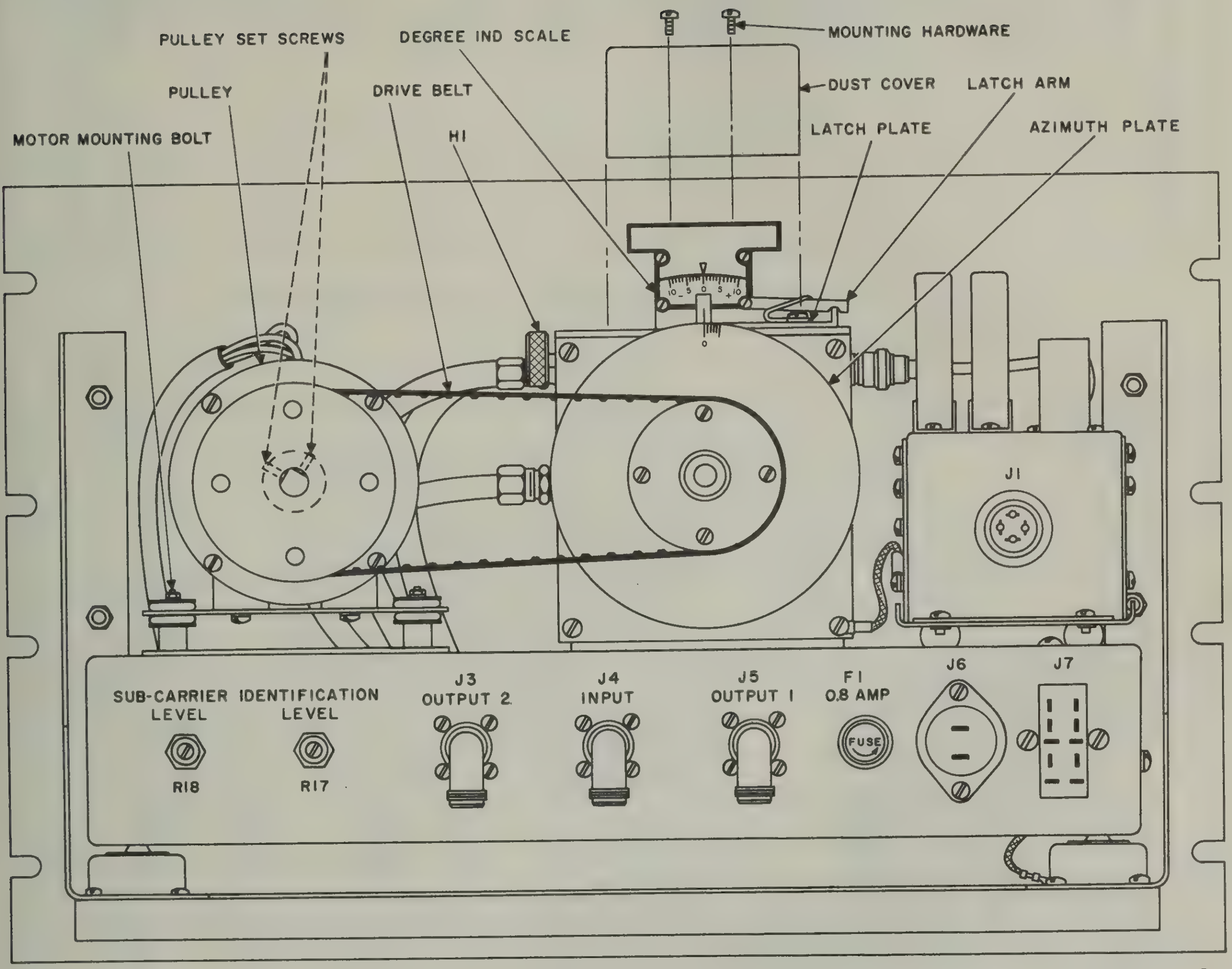
Figure 29. Typical electrical equipment cabinet, fuse location.



TM215-39 ①

1. Serial numbers 613 and below

Figure 30. Electrical Goniometer GO-12/FRN-20, fuse and control locations.



2. Serial numbers 614 and above

Figure 30—Continued.

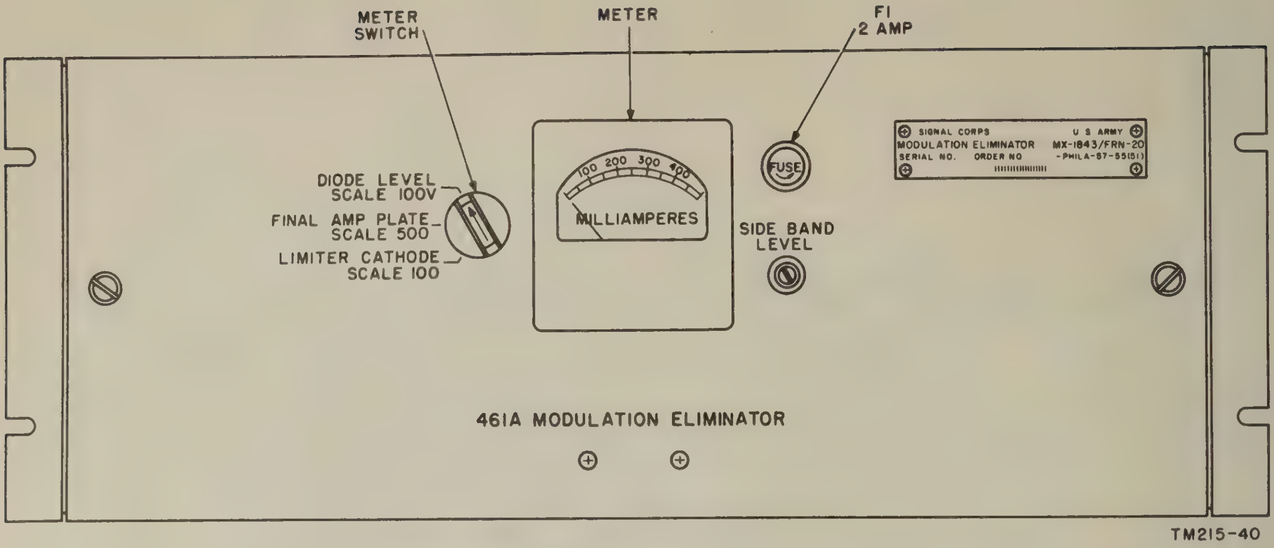

METER SWITCH
METER
F1
2 AMP
DIODE LEVEL SCALE 100V
FINAL AMP PLATE SCALE 500
LIMITER CATHODE SCALE 100
100 200 300 400
MILLIAMPERES
FUSE
SIDE BAND LEVEL
SIGNAL CORPS U S ARMY
MODULATION ELIMINATOR MX-1843/FRN-20
SERIAL NO. ORDER NO -PHILA-57-55(51)
461A MODULATION ELIMINATOR
TM215-40

Figure 31. Modulation Eliminator MX–1843/FRN–20, fuse and control locations.

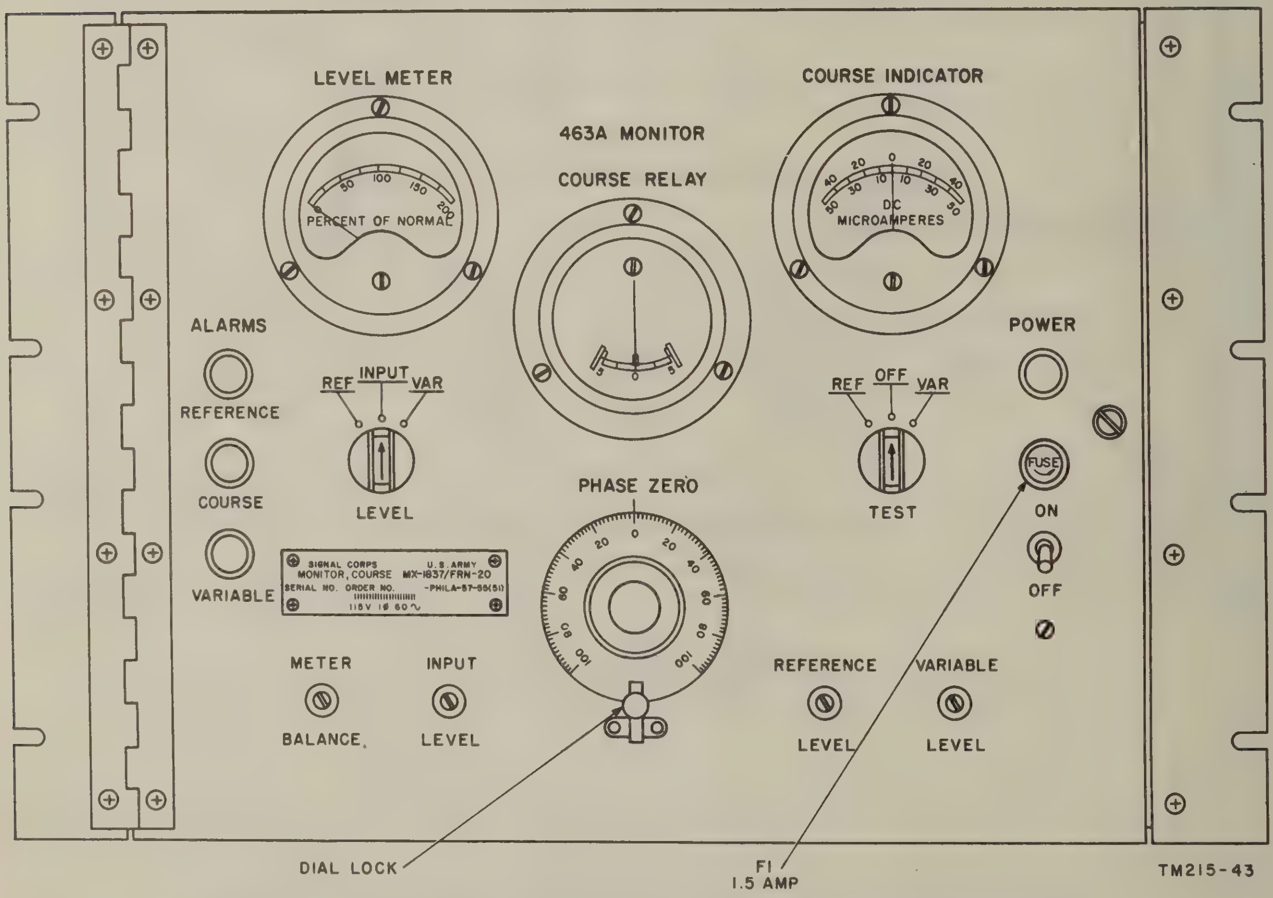


Figure 32. Course Monitor MX–1837/FRN–20, fuse, control, and indicator locations.

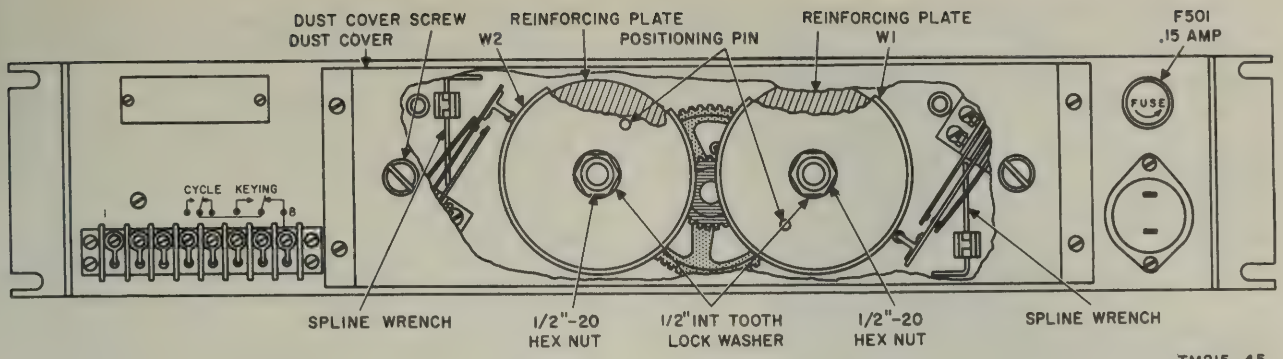


Figure 33. Keyer KY-175/FRN, fuse and code and cycle wheel locations.

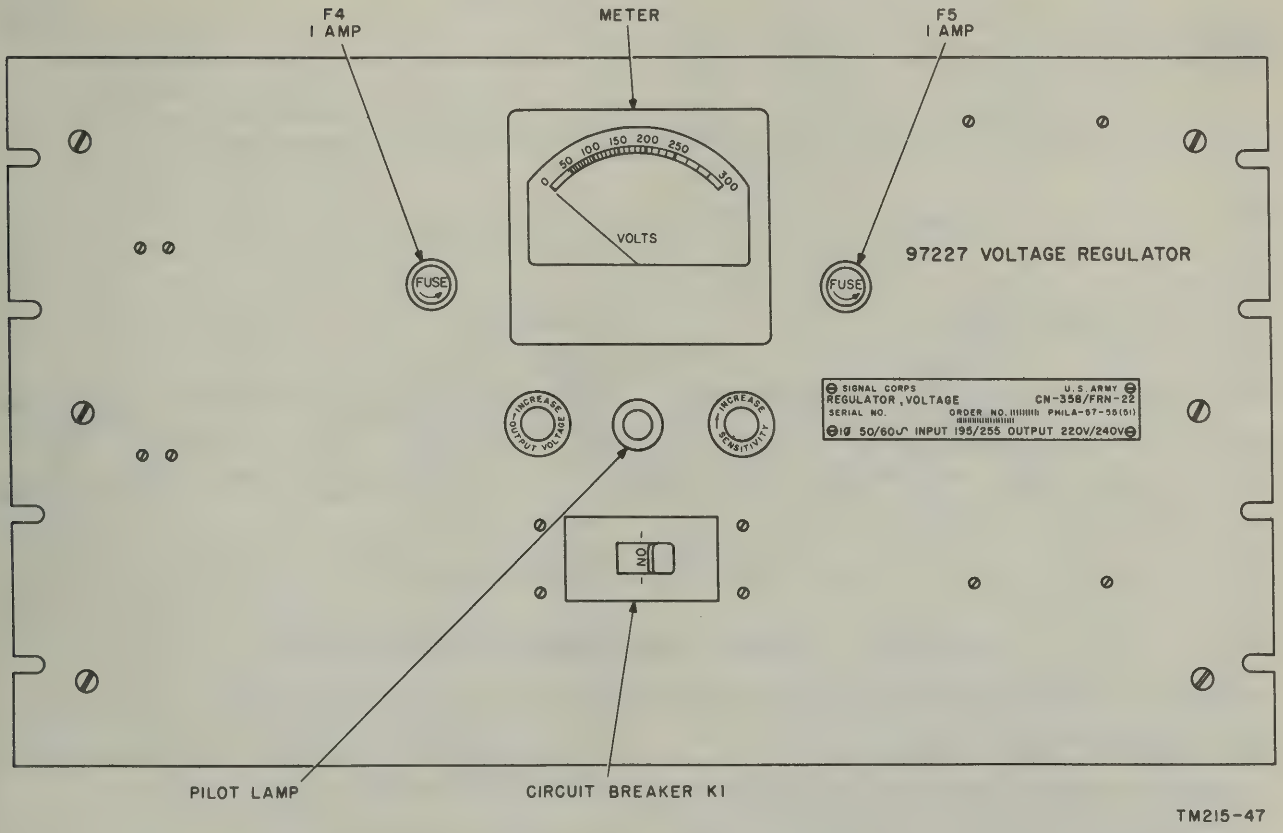


Figure 34. Voltage Regulator CN-358/FRN-22, fuse, control, and indicator locations.

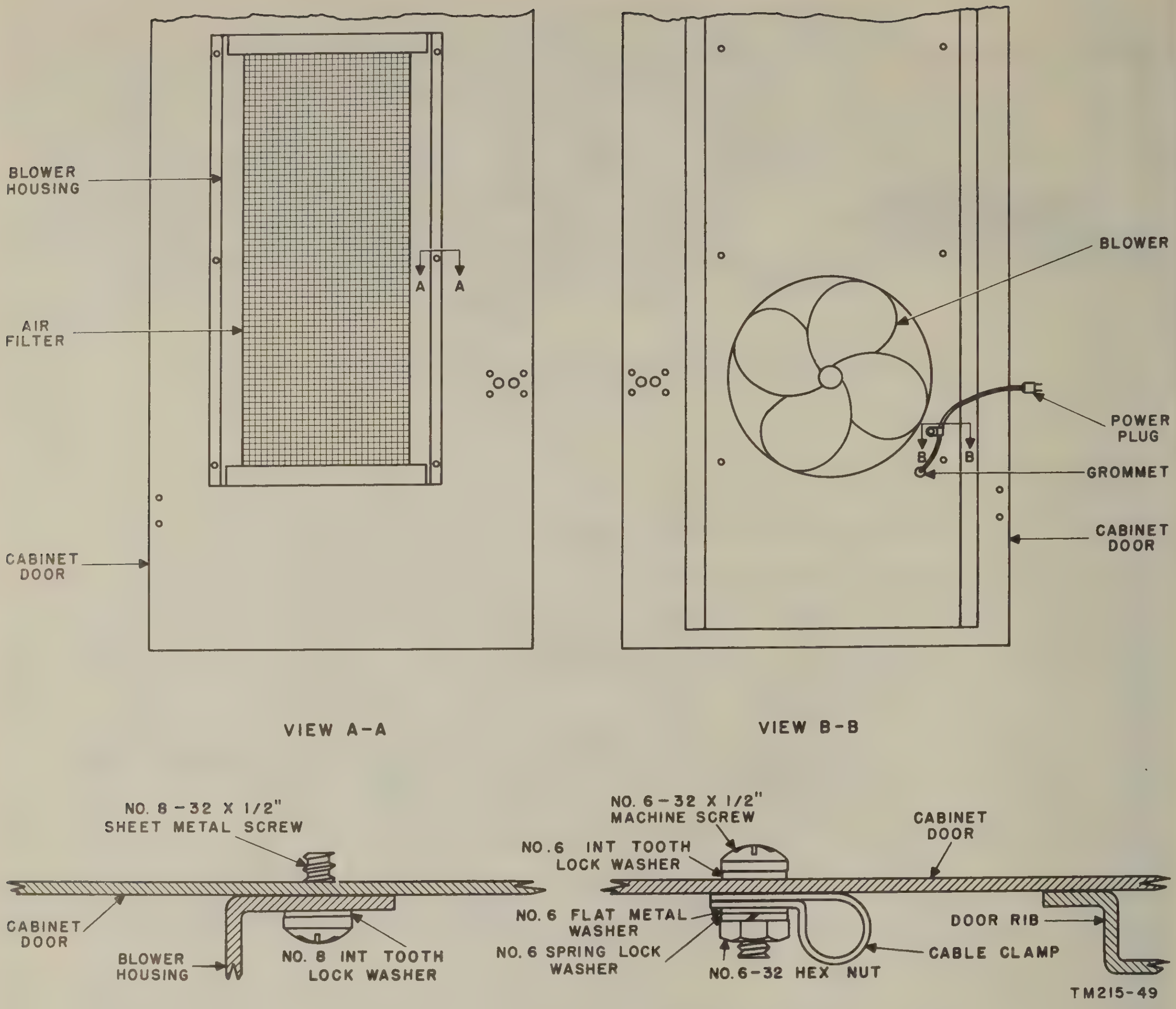


Figure 35. Cabinet blower installation diagram.

Section III. INITIAL ADJUSTMENT OF EQUIPMENT

Note. The procedures described in this section should be performed by a field radio repairman.

30. Extent of Initial Adjustments

Before the omnirange set can be used for routine operation, the procedures outlined in paragraphs 32 through 60 must be performed. When the assigned operating frequency is changed, perform the antenna tuning procedure (par. 33), transmitter tuning procedure (par. 39), AN/FRA–14 tuning procedure (par. 43), modulation level adjustments (pars. 45 and 46), monitor adjustments (pars. 48–54), level discrepancy adjustments (par. 56), final adjustments (par. 57), flight check (par. 58), and commissioning the station (par. 60).

31. Tools and Test Equipment Required

Tools, test equipment, and miscellaneous test items required are listed below. The tools and materials contained in Tool Equipment TE–113 are listed in Department of the Army Supply Manual SIG 6 TE–113.

a. Tools. One Tool Equipment TE–113.

b. Test Equipment.

Nomenclature	Common name	Manual
Multimeter ME–77/U.	Multimeter	TM 11–6625–203–12
Radio Frequency Wattmeter AN/URM–43A.	Wattmeter	TM 11–5133
Audio Oscillator TS–382A/U.	Audio Oscillator.	TM 11–2684A
Electronic Multimeter, TS–505/U.	Vtvm	TM 11–5511
Oscilloscope, Du Mont Model 2559A.	Oscilloscope	

c. Miscellaneous Test Items.

Quantity	Item	Common name
2	Safety door switch (cap portion), Bryant Electric Company No. 4600A.	Interlock jumper plug.
1	Three-foot length of RG–8/U coaxial cable terminated at each end in a UG–21D/U plug.	Wattmeter test cable.
1	Ten-foot length of RG–8/U coaxial cable terminated at one end in a UG–21D/U plug.	Oscilloscope test cable.
1	Resistor, 500-ohm, 2-watt	Dummy load resistor.

32. Preparation for Adjustments

Make the preliminary control settings and adjustment preparations described below before starting the initial adjustment procedure. Operating controls are listed and described in paragraph 38, in TM 11–5825–205–12.

a. Antenna Pedestal. The locations of circuit breakers and autotransformer T1001 on the antenna pedestal are shown in figure 201.

(1) Set all circuit breakers on the antenna pedestal to OFF.

(2) Remove the eight screws that hold the cover plate in place on the right side of autotransformer T1001 and remove the cover plate.

***Warning:* Dangerous voltages exist on the terminals of autotransformer T1001 when circuit breaker K1001 is at ON. Recheck circuit breaker K1001 to be sure that it is at OFF.**

(3) Observe the connections to the transformer terminals. A blue wire and a black wire should connect to one terminal marked "230." A red wire and a yellow wire should connect to the other terminal marked "230." An orange wire should connect to the terminal marked "0." If connections have not been made as described, make the proper connections at this time.

(4) Replace the transformer cover plate and fasten it in position with the screws.

b. Electrical Equipment Cabinet CY–1897/FRN–22. The locations of individual components in the CY–1897/FRN–22 are shown in figure 2, TM 11–5825–205–12.

(1) Set the ON-OFF switch on the monitor (fig. 32) to OFF.

(2) On the RE–247/FRN–22 (fig. 262), set the EQUIPMENT NO. 1 and EQUIPMENT NO. 2 OPERATE switches to 460A, and the EQUIPMENT NO. 1 and EQUIPMENT NO. 2 TEST switches to OFF.

(3) Set the circuit breaker on the voltage regulator (fig. 34) to OFF.

(4) Open the rear door of the cabinet and turn R15 (fig. 25) at the rear of each O–373/FRN to the full counterclockwise position. Be sure to close the door tightly.

c. Electrical Equipment Cabinet CY–1899/FRN–22. The locations of individual components in *each* CY–1899/FRN–22 are shown in figures 2 and 3 of TM 11–5085–205–12.

(1) Turn the MODULATION GAIN control on *each* transmitter (fig. 36) to the full counterclockwise position. On all transmitter tuning controls which have a white dot on the end of the shaft, set the control so that the white dot is in the 12 o'clock position.

(2) Set the ON-OFF switch on *each* PP–1331/FRN–20 (fig. 242) to off.

(3) Open the rear door of the cabinet and turn IDENTIFICATION LEVEL control R17 and SUB-CARRIER LEVEL control R18 on *each* goniometer ((1) fig. 30) to the full counterclockwise position. Be sure to close the door tightly.

d. Electrical Equipment Cabinet CY–2274/FRN–22A. The locations of individual components in the CY–2274/FRN–22A are shown in figure 3, TM 11–5825–205–12.

(1) On *each* O–371/FRN–20 (fig. 37), turn the OSC FREQ control to the center of its range and the REGULATOR control fully clockwise.

(2) On *each* AM–1246/FRN–20 (fig. 38), turn the LEVEL control fully counterclockwise, and the OVERLOAD CONTROL fully clockwise.

(3) Open the door of the cabinet and remove thermal relay K902 from *each* O–371/FRN–20 (fig. 22). Be sure to close the door tightly.

e. Electrical Equipment Cabinet CY–1826/FRN–20. The locations of individual components in the remote control cabinet are shown in figure 6, TM 11–5825–205–12.

(1) Place the ALARM SELECTOR in the *down* position.

(2) Connect the power cable to a 115-volt ac power source.

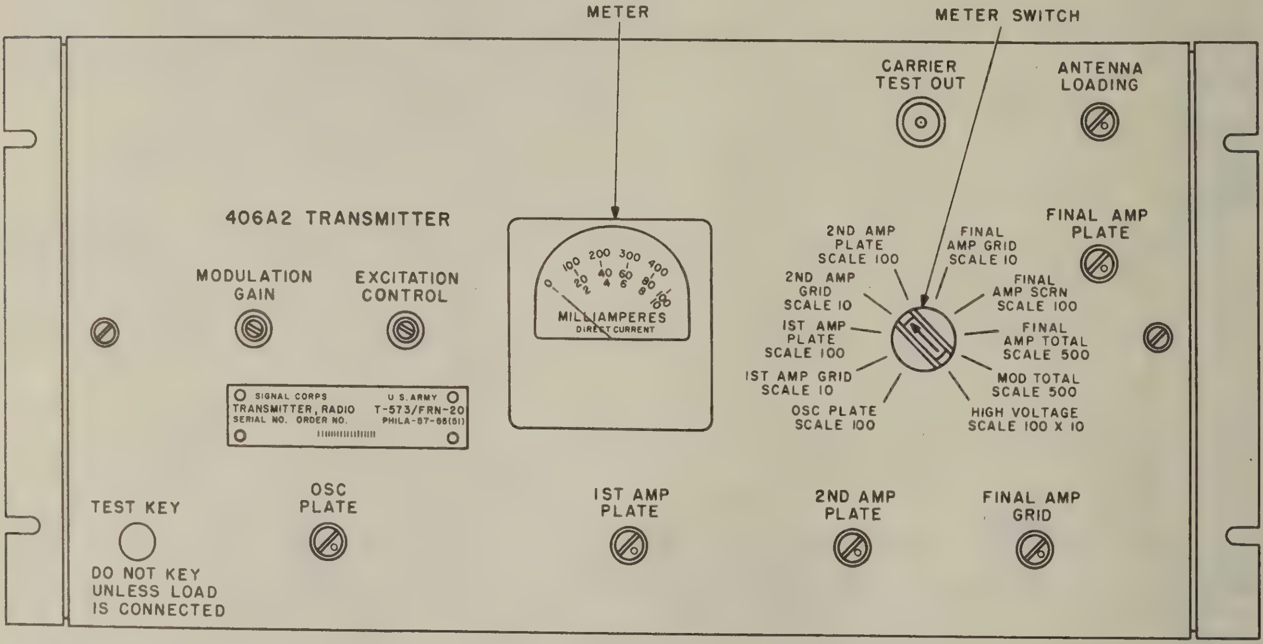


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Figure 36. Radio Transmitter T–573/FRN–20, control locations.

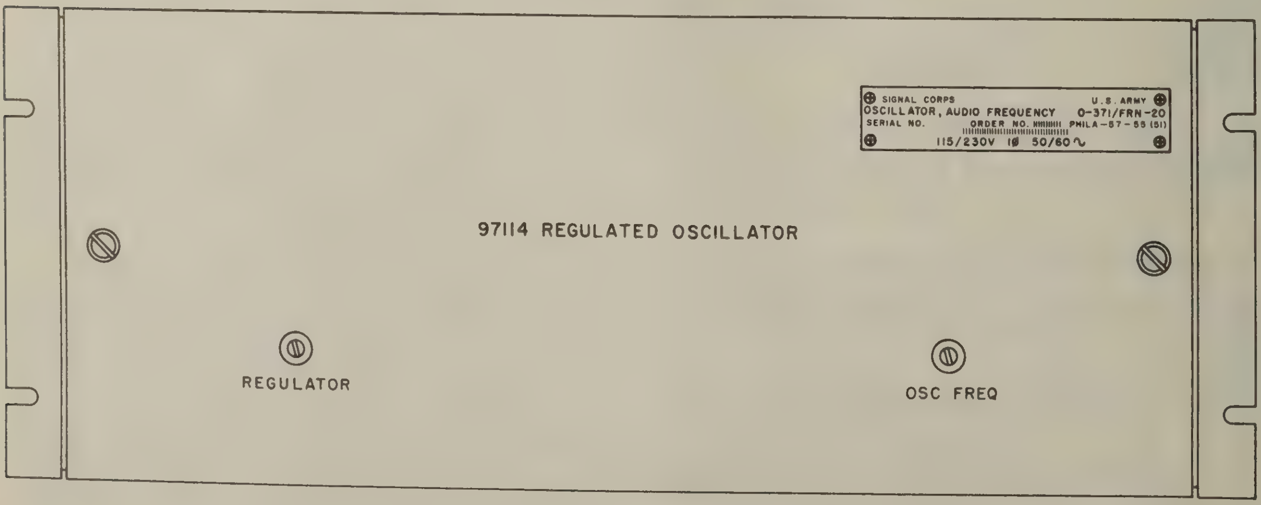

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Figure 37. Audio-Frequency Oscillator O–371/FRN–20, control locations.

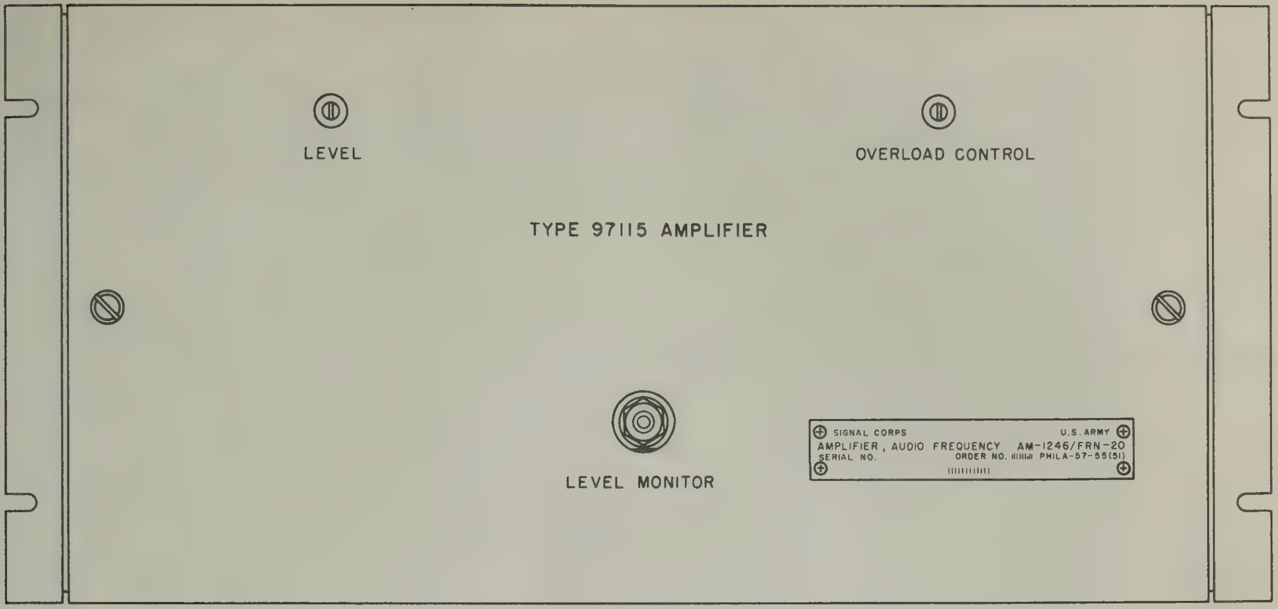


Figure 38. Audio-Frequency Amplifier AM–1246/FRN–20, control locations.

33. Tuning Adjustments on Antenna AT–669/FRN–22

Normally, when the transmitter frequency to be used is known, the antenna is completely adjusted at the factory. If the transmitter frequency to be used is unknown prior to shipment, the necessary tuning adjustments must be made in the field. Perform the operations outlined below.

a. All tuning adjustments are located inside the antenna (figs. 41–43). To reach the adjustments, remove the screws which hold any two *opposite* radomes in place and remove the radomes.

b. A typical antenna tuning chart is shown in figure 40. This type of chart accompanies each antenna and includes all the data for the adjustment of that antenna. Note that the chart is divided into two frequency ranges; one for the range between 108 megacycles (mc) and 112 mc, and the other for the range between 112 mc and 118 mc. In the following adjustment procedure, an example setting will be given for each adjustment. These settings are taken from the tuning chart (fig. 40) and are based on a transmitter frequency of 112.5 mc.

***Caution:* Do not use the example settings in the following procedure to adjust any antenna. These settings and the typical tuning chart are to be used as a *guide only*. Refer to the tuning chart which accompanies the antenna for the actual adjustment settings to be made. *Under no circumstances* should any adjustments other than those described in *c* through *i* below be made in the *field*. Loosening the screws which hold the dielectric strip between the slots will disturb the precise alinement of the slot loading fins and require recalibration of the antenna at the factory.**

c. Note the positions of slot tuning inductance L1 and slot tuning capacitor C3 (fig. 41). These two adjustments are in the *upper* portion of the antenna, and are identified with the word "upper" on the tuning chart.

d. Slot tuning inductance L1 is mounted on eight parallel bars which are arranged in *pairs*. One bar of *each pair* has a calibrated scale. The correct setting for slot tuning inductance L1 is shown along the top edge of the tuning chart. Note that on the tuning chart (fig. 40) this setting is 2.6 for 112.5 mc. Loosen the eight wingnuts holding L1. Position L1 so that the upper edges of its clamps are at the point on the calibrated bars corresponding to the setting given on the antenna tuning chart. *Be sure that L1 is in a horizontal position and not tilted or cocked at an angle.* Then tighten the wingnuts.

***Caution:* During the adjustment of slot tuning capacitor C3 (*e* below), hold the capacitor with one hand to prevent it from slipping out and falling into the antenna pedestal when the clamp screws are loosened.**

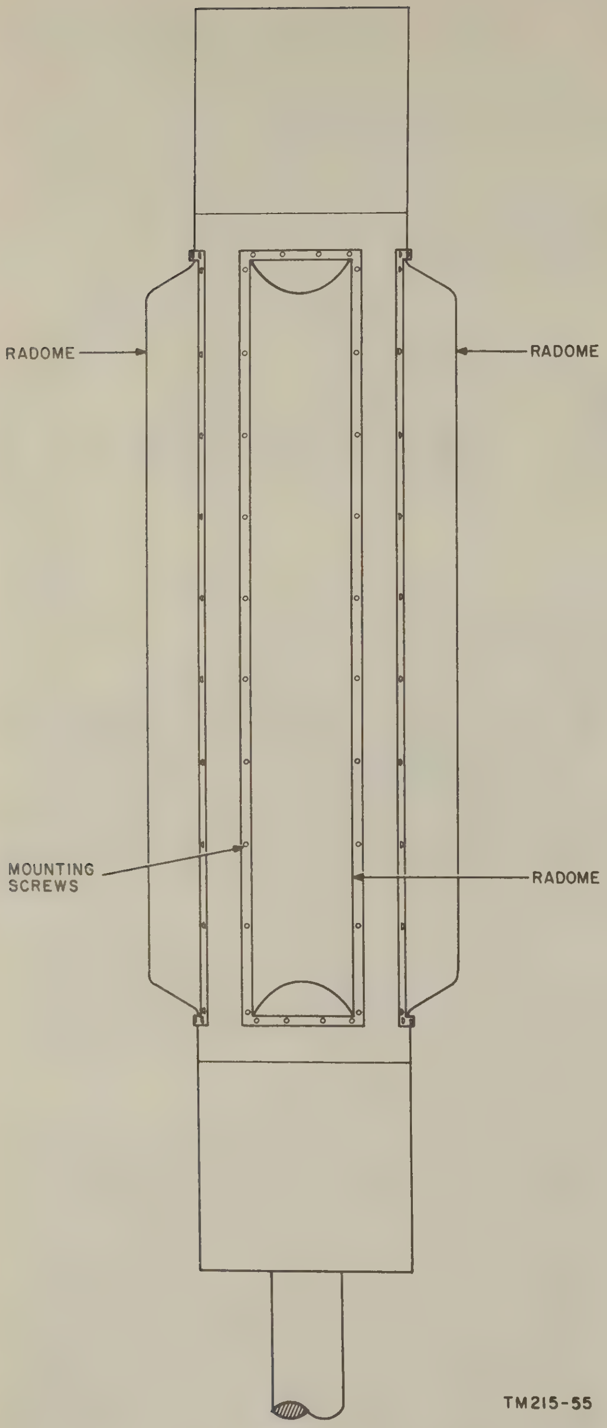


Figure 39. Antenna AT–669/FRN–22, radome locations.

e. The correct setting for slot tuning capacitor C3 is also shown along the top edge of the tuning chart. On the typical tuning chart, this setting is 5.0 for 112.5 mc. Loosen the two clamp screws and slide C3 either in or out until the proper mark on its calibrated scale is even with the top of the clamp. Then tighten the clamp screws.

f. Note the positions of slot tuning inductance L2 and slot tuning capacitor C4 shown in figure 42. These two tuning adjustments will be found in the *lower* portion of the antenna and, therefore, will be identified with the word "lower" on the tuning chart.

g. The correct setting for slot tuning inductance L2 will be found on the appropriate curve on the lower portion of the tuning chart. On the typical tuning chart, this is 0.5 for 112.5 mc. Loosen the eight wingnuts holding L2. Position L2 so that the lower edges of its clamps are at the point on the calibrated bars corresponding to the setting given on the antenna tuning chart. *Be sure that L2 is in a horizontal position and not tilted or cocked at an angle.* Then tighten the wingnuts.

***Caution:* During the adjustment of slot tuning capacitor C4 (*h* below), hold capacitor C4 with one hand to prevent it from slipping out and falling into the antenna pedestal when the clamp screws are loosened.**

h. The correct setting for slot tuning capacitor C4 will be found on the appropriate curve in the center of the tuning chart. On the typical tuning chart, this setting would be 9.3 for 112.5 mc. Refer to figure 42. Loosen the two clamp screws and slide C4 either in or out until the proper mark on its calibrated scale is even with the bottom of the clamp. Then tighten the clamp screws.

i. The correct settings for feeder tuning capacitors C1 and C2 will be found on the appropriate curve on the upper portion of the tuning chart. On the typical tuning chart, both capacitors would be set to 56 for 112.5 mc. Note the location of feeder tuning capacitors C1 and C2 shown in figure 43. These two capacitors will be found in the lower portion of the antenna below the bottom ends of the slots. Loosen the thumbscrew dial locks. Set both capacitor dials so that the proper number is alined with the indicator mark. Then tighten the dial locks.

***Caution:* When replacing radomes (*j below*), be very careful to see that all radome gaskets provide a good weather seal. Be sure that each radome is replaced with the end marked "top" toward the top of the antenna. If a radome is not marked with the word "top," note the end**

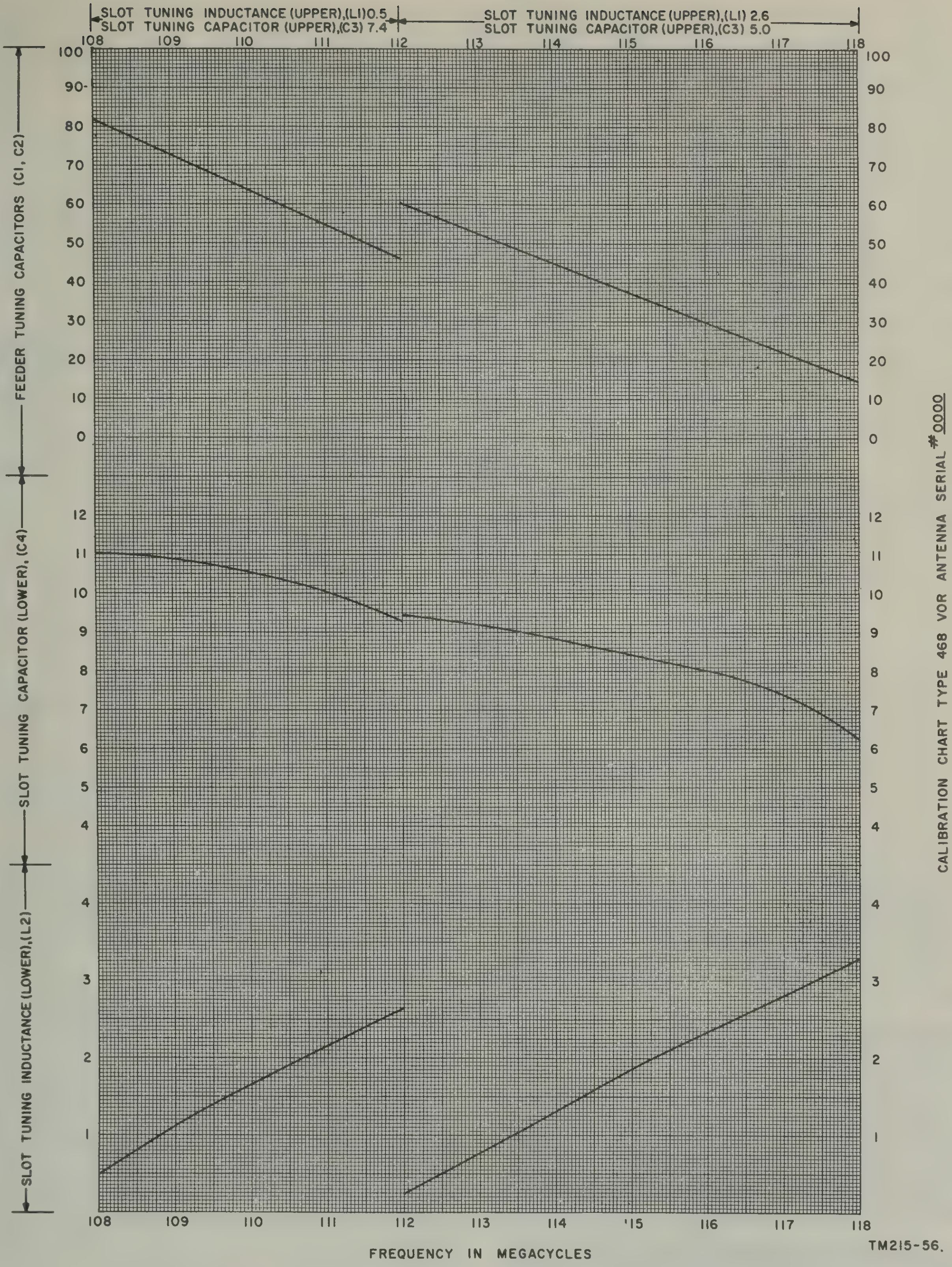


Figure 40. Antenna AT–669/FRN–22, typical tuning chart.

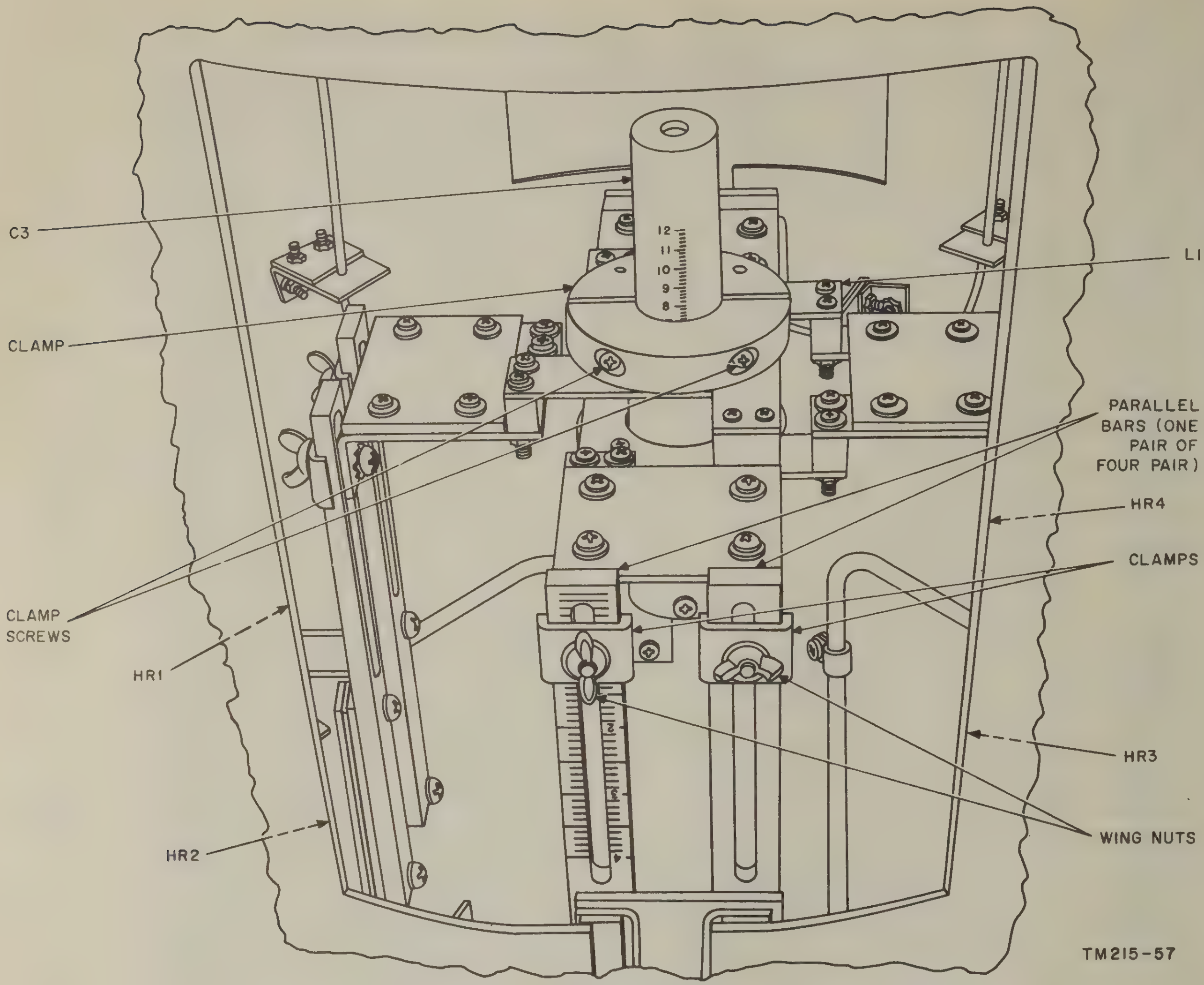


Figure 41. Antenna AT–669/FRN–22, upper slot tuning adjustment locations.

of the radome which has a gasket the full width of the radome. Place this end of the radome toward the top of the antenna.

j. Replace the radomes and tighten the screws securely.

34. Adjustment of Voltage Regulator CN–358/FRN–22

(fig. 34)

Caution: **Observe the meter on the front panel. Be sure the meter pointer is at zero. If necessary, use the adjustment screw on the meter to zero the pointer.**

a. Before starting adjustment of the voltage regulator, set circuit breakers K1001, K1005, K1007, and K1015 (fig. 201) on the antenna pedestal to ON.

b. Set the circuit breaker on the front panel of the voltage regulator to ON. The shelter lights should light. The red pilot lamp should light and the meter should indicate some value of output voltage.

c. Unscrew the protective cap on the INCREASE OUTPUT VOLTAGE control. Adjust the control for an output of exactly 230 volts as indicated by the meter.

d. Unscrew the protective cap on the INCREASE SENSITIVITY control. Rotate the control in a clockwise direction to the point at which the regulator *hunts* (motor operates continuously). Turn the control approximately ⅛ turn counterclockwise until the regulator stops hunting. The optimum setting for this control can best be determined by experience with each individual installation.

e. Replace the protective caps on both controls.

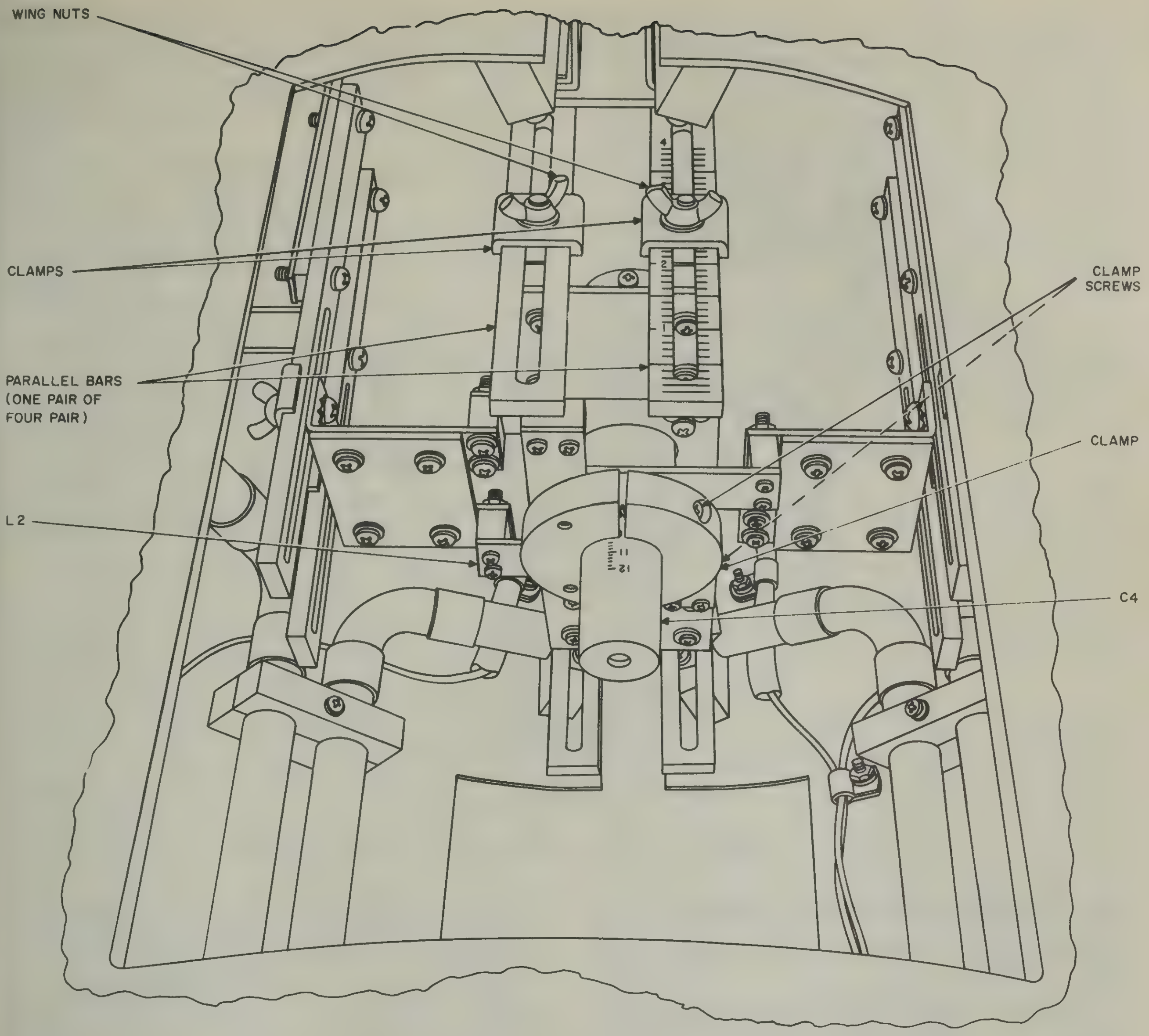


Figure 42. Antenna AT–669/FRN–22, lower slot tuning adjustment locations.

Note. Check the voltage output reading on the meter of the voltage regulator as load changes occur due to additional components of the omnirange set being placed in operation as they are adjusted. If necessary, reset the INCREASE OUTPUT VOLTAGE control to maintain a constant output of 230 volts ac, and reset the INCREASE SENSITIVITY control for the desired sensitivity as described in *d* above.

35. Adjustment of Power Supply PP–1415/FRN–22

(fig. 244, p. 351)

The PP–1415/FRN–22 is located in the CY–1897/FRN–22 (fig. 2, TM 11–5825–205–12). The secondary of transformer T1201 has four taps which are connected to terminals 1, 2, 3, and 4 on TB1201. Normally, metallic rectifier CR1201 is connected to terminal 3 of TB1201. However, it is desirable to check this tap setting before proceeding to other equipment adjustments.

a. Two knurled thumbscrews hold the front panel in place. Loosen these thumbscrews and remove the front panel.

b. If the wire from metallic rectifier CR1201 is not already connected to terminal 3 of TB1201, make the connection.

c. Replace the front panel.

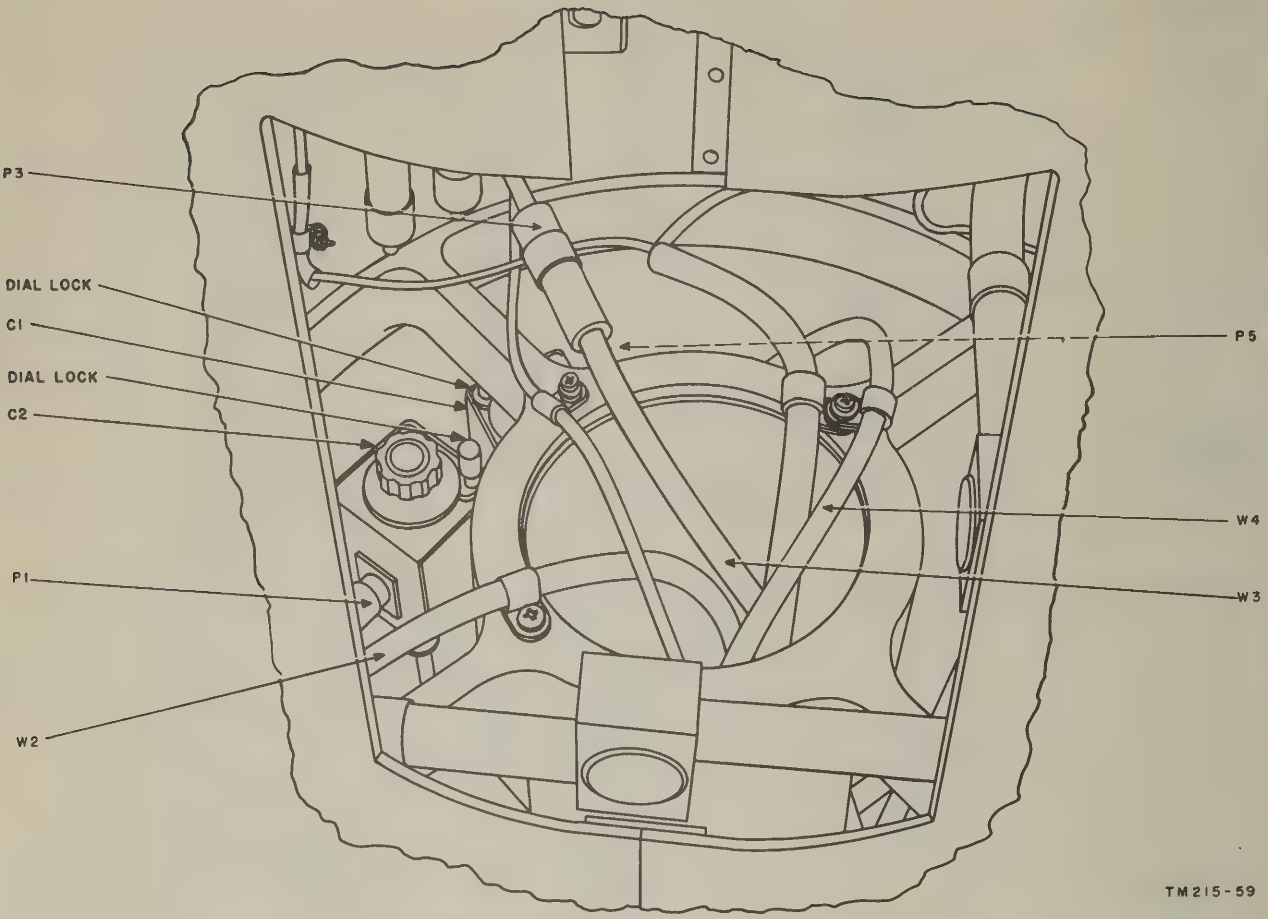


Figure 43. Antenna AT–669/FRN–22, feeder tuning adjustment locations.

36. Adjustment of Dialing Circuits

a. Set circuit breakers K1003 and K1004 (fig. 201) to ON.

***Warning:* When circuit breakers K1003 and K1004 are at ON, dangerous voltages exist within the CY–1897/FRN–22. Be careful when making adjustments on components in this cabinet. Always use properly insulated tools and avoid touching exposed terminals, contacts, or other potential sources of high voltage.**

b. The C–1738/FRN–20 is located in the CY–1897/FRN–22 (fig. 2, TM 11–5825–205–12). Remove the two thumbnuts and the dust cover (fig. 246).

c. Set the LOCAL-REMOTE switch to LOCAL.

d. Dial 10.

e. Check the contact arm on minor switch K201 (fig. 247) to see that it stops at the number 10 contact position. Contact 10 is the end contact that has a wire connection.

f. Dial 10 several more times. Each time, check to see that the contact arm on K201 stops at the number 10 contact position.

g. Connections to the CY–1897/FRN–22 are shown in figure 16. Disconnect the telephone control line from terminals 1 and 2 of terminal board TB804.

h. Use Multimeter AN/URM–103 and measure the loop resistance of the telephone line. With the other end of the telephone line connected, the resistance reading will be approximately 100 ohms greater than it is when the line wires are shorted together. Record the resistance reading so that it can be referred to by maintenance personnel, and note whether the line was connected or the wires were shorted together.

i. Reconnect the telephone control line to terminals 1 and 2 of TB804.

j. Two knurled thumbscrews hold the front panel of the C–1738/FRN–20 in place. Loosen the thumbscrews and pull the front panel away from the unit. Two hangers are mounted at the rear of the panel (fig. 44). Hook these hangers over the flange on the bottom of the chassis to keep the panel in an operating position.

k. Set the FUNCTION switch on the multimeter in the DIRECT position. Measure the voltage across the coil in relay 0 202 (fig. 247). Leave the test prods connected for future adjustments.

l. Set circuit breaker K1011 to ON (fig. 201).

***Warning:* When circuit breaker K1011 is at ON, dangerous voltages will exist within the No. 1 CY–1899/FRN–22. Be careful when making adjustments on components in this cabinet. Always use properly insulated tools and avoid touching exposed terminals, contacts, or other potential sources of high voltage.**

m. Set the ON-off switch on the front panel of the PP–1331/FRN–20 to ON (fig. 242).

n. At the remote control point, the ALARM SELECTOR on the remote control unit should be in the *down* position (fig. 6, TM 11–5825–205–12). When 9 is dialed (*o* below), the buzzer on the remote control unit will sound. Notify the operator at the remote point to listen for the buzzer. Give instructions that, when the buzzer sounds, the operator is to set the ALARM SELECTOR to the *center* position to silence the buzzer, wait for a signal from the omnirange site which will be indicated by the buzzer sounding intermittently, and then listen at the remote handset for instructions.

o. Dial 9. When 9 is dialed, the No. 1 transmitting equipment is placed in a warmup condition.

p. Set the LOCAL-REMOTE switch to REMOTE.

q. Two sound-powered handsets (figs. 2 and 4, TM 11–5825–205–12) provide an intercommunication system between the remote control point and the shelter. The location of the RING-TALK switch is shown in figure 246. When the RING-TALK switch is placed at RING, a buzzer will sound at the remote control point. To signal the operator at the remote control point, raise the RING-TALK switch to RING, hold in this position for about 2 seconds, and release. Repeat this procedure several times.

r. After signaling the operator, hold the RING-TALK switch at TALK. Tell the operator to listen at his handset for further instructions. Be sure to hold the RING-TALK switch at TALK while speaking to the operator.

s. Tell the operator to dial 9 and hold the dial in the *cocked* position until the buzzer at the remote point sounds intermittently. Tell the operator to release the dial as soon as the buzzer sounds.

***Warning:* A potential of 100 volts ac may be present on resistor R201. When making the adjustment given in *t* below, use an insulated screwdriver and avoid coming in contact with R201 or other component parts.**

t. While the operator holds the dial in the cocked position, adjust the slide on resistor R201 (fig. 44) to obtain an indication of 10 to 14 volts on the multimeter across the coil of relay 0 202 (*k* above). If the meter pointer goes offscale to the left, turn the multimeter FUNCTION switch counterclockwise to the *reverse* position.

u. Use the RING-TALK switch and signal the operator to release the dial. Remove the multimeter leads from the coil of relay 0 202.

v. Signal the remote control point and, using the handset, ask the operator to dial 9 at 30-second intervals. As the operator dials, check the contact arm on minor switch K201 (fig. 24) to see that it stops at the 9 contact position. When resistor R201 is properly adjusted, dialing from the remote control unit should be as positive as dialing from the C–1738/FRN–20. If proper dialing action cannot be obtained from the remote point, readjust R201 to slightly increase the voltage on the coil of relay 0 202. *Do not exceed the 14-volt maximum.*

w. Notify the operator at the remote point when the proper dialing action is obtained. Tell the operator to expect the buzzer to sound when 10 is dialed (*x* below), and when this occurs, to set the ALARM SELECTOR to the *down* position to silence the buzzer.

x. Dial 10 to turn the transmitting equipment off.

y. Replace the dust cover at the rear of the C–1738/FRN–20.

z. Replace the front panel and place the LOCAL-REMOTE switch at LOCAL.

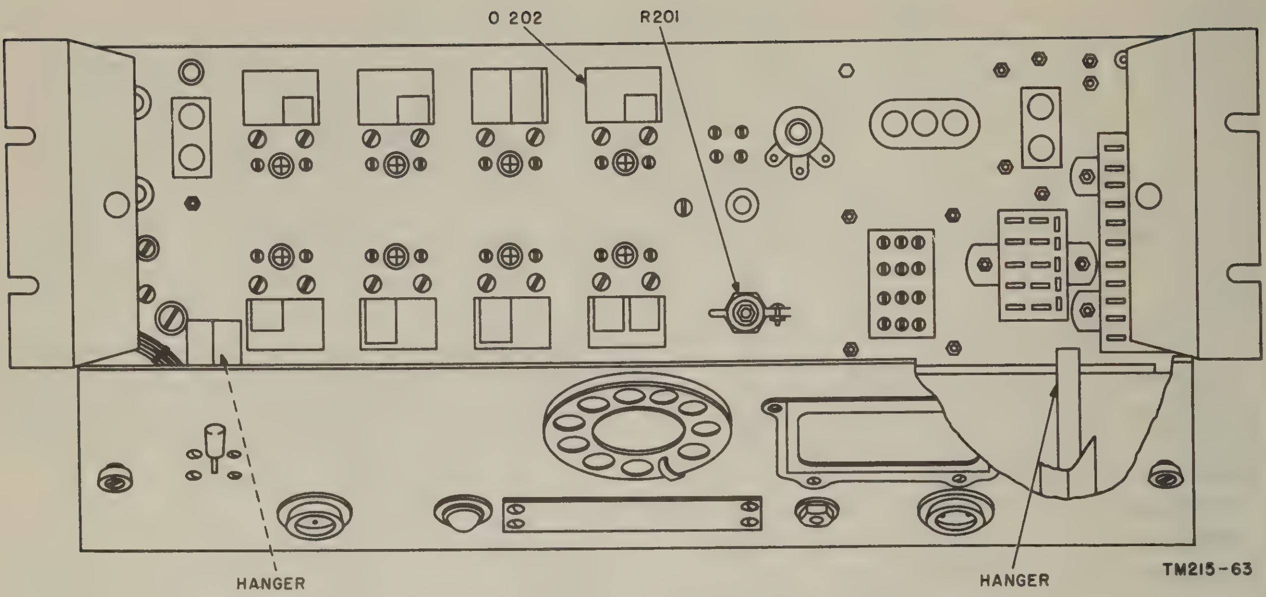


Figure 44. Radio Set Control C–1738/FRN–20, front panel removed.

37. Adjustment of No. 1 Transmitting Equipment

Note. The No. 1 transmitting equipment consists of all components in the No. 1 CY–1899/FRN–22, the No. 1 O–371/FRN–20, and the No. 1 AM–1246/FRN–20 in the CY–2274/FRN–22A, plus the No. 1 O–373/FRN and the No. 1 keyer in the CY–1897/FRN–22. These components are all shown in figure 2 of TM 11–5825–205–12.

The adjustment procedures for the No. 1 transmitting equipment are outlined in paragraphs 38 through 46. Because of the interdependence of various components, adjustments to the AN/FRA–14 (par. 43) and AM–1247/FRN–20 (par. 49) have been included with the adjustments for the No. 1 transmitting equipment. Before starting the adjustment procedures, disconnect the power cable for the remote control unit and the AM–1247/FRN–20 (located at the remote point) from the 115-volt ac power source. The purpose of disconnecting the power cable is to avoid causing alarm signals at the remote control point as the transmitting equipment is adjusted.

38. Adjustment of Power Supply PP–1331/FRN–20

(fig. 11, p. 24.)

a. Bias Voltage Adjustment.

(1) Open the rear door of the CY–1899/FRN–22. Insert an interlock jumper plug into the female contacts of interlock switch S1801 (fig. 226). Leave the cabinet door open.

(2) The front panel of the PP–1331/FRN–20 is held in place by two knurled thumbscrews. Loosen the thumbscrews and remove the front panel.

(3) Insert an interlock jumper plug into interlock switch S1 (fig. 242).

(4) Set the voltage range on the multimeter to 250 volts and the FUNCTION switch to DIRECT. Connect the negative lead to the adjustable slide of resistor R5 and the positive lead to the chassis.

(5) Dial 9. The tube filaments will light on all components in the transmitter cabinet.

(6) Check the reading on the multimeter connected to resistor R5. When the slide on R5 is properly adjusted, the multimeter will indicate −100 volts. If the multimeter does not indicate −100 volts, dial 10. This turns the transmitting equipment off and all tube filaments will go out. Proceed with the instructions given in (7) below if resistor R5 requires further adjustment; otherwise perform (8) below.

***Warning:* To avoid coming in contact with high voltages during the procedure given in (7) below, do not attempt to readjust resistor R5 until after 10 has been dialed.**

(7) Loosen the screw holding the slide on resistor R5, move the slide slightly, and retighten the screw. Dial 9 and again check the reading on the multimeter. Repeat the adjustment on resistor R5 until the multimeter indicates −100 volts.

(8) After resistor R5 has been properly adjusted, dial 10. Disconnect the multimeter.

b. Simplex Voltage Adjustment.

(1) Disconnect the telephone control line from terminals 1 and 2 of terminal board TB804 in the CY–1897/FRN–22 (fig. 16).

(2) At the rear of the transmitter (fig. 16), remove plug P1806 from receptacle J1 and plug P1807 from receptacle J2.

(3) The location of terminal board TB1 at the rear of the PP–1331/FRN–20 is shown in figure 16. Use the 50-volt range of the multimeter and set the FUNCTION switch to DIRECT. Connect the negative lead of the multimeter to terminal 10 and the positive lead to terminal 26.

(4) Dial 9 and set the LOCAL-REMOTE switch to REMOTE.

(5) Adjust resistor R9 (fig. 20) to obtain a 12-volt indication on the multimeter.

(6) Set the LOCAL-REMOTE switch to LOCAL, and dial 10. Disconnect the multimeter.

Note. Do not replace the front panel on the PP–1331/FRN–20. The bias voltage on resistor R5 should be rechecked (*a*(4) above) after the transmitter has been completely tuned (par. 39).

(7) Reconnect the telephone control line to terminals 1 and 2 of terminal board TB804.

(8) At the rear of the transmitter, reconnect plug P1806 to receptacle J1 and plug P1807 to receptacle J2 (fig. 16).

39. Tuning Adjustments on Radio Transmitter T–573/FRN–20

Caution: **To prevent damage to modulator tubes V7 and V8, which would result from operating them without plate voltage while screen voltage is applied, remove these tubes from the transmitter (fig. 19).**

a. Remove the 500-volt supply lead from the transmitter (fig. 16) by disconnecting plug P1807 from receptacle J2.

b. Disconnect plug P18 from receptacle J1802 on the top of the CY–1899/FRN–22 (fig. 16).

c. Use the 60-watt range of the wattmeter and measure the power output of the transmitter. Follow the instructions given in TM 11–5133. Connect one end of the wattmeter test cable (par. 31*c*) to receptacle J1802 on top of the CY–1899/FRN–22. Connect the other end of the test cable to the wattmeter.

d. Dial 9.

e. Transmitter tuning and adjustment controls are shown in figure 36. Press the TEST KEY. The TEST KEY is of the locking type and will apply high voltage to the transmitter until it is pulled out.

f. Turn the meter switch to 1ST AMP GRID. Adjust the OSC PLATE tuning control for a maximum indication on the meter.

g. Turn the meter switch to 2ND AMP GRID. Adjust the 1ST AMP PLATE tuning control for a maximum indication on the meter.

h. Turn the meter switch to 2ND AMP PLATE. Rotate the EXCITATION CONTROL fully clockwise, and adjust the 2ND AMP PLATE tuning control for a minimum indication on the meter.

i. Turn the meter switch to FINAL AMP GRID. Adjust the FINAL AMP GRID tuning control for a maximum indication on the meter. If the meter pointer goes off-scale, rotate the EXCITATION CONTROL counterclockwise until the pointer is on scale.

j. Leave the meter switch at FINAL AMP GRID. Readjust the 2ND AMP PLATE tuning control for a maximum indication on the meter. Readjust the FINAL AMP GRID tuning control for a maximum indication on the meter. Adjust the EXCITATION CONTROL for a 10-milliampere indication on the meter.

k. Set the ANTENNA LOADING control so that the white dot on the end of the shaft is in the 12 o'clock (maximum capacity) position.

Warning: **Bias voltage is present on neutralizing capacitors C26 and C27. Use an insulated ¼-inch socket wrench if it is necessary to adjust C26 and C27 (*l* below).**

l. Rotate the FINAL AMP PLATE tuning control through 180°, and note any dip in the meter reading. If a dip occurs, neutralizing capacitors C26 and C27 must be adjusted. Capacitors C26 and C27 (fig. 19) can be adjusted without removing the shield plate. Loosen the nuts which hold capacitors C26 and C27 in place. Adjust the position of each capacitor plate to change the spacing between it and the corresponding plate (not the plate caps of V4). When no dip occurs during rotation of the FINAL AMP PLATE tuning control, the transmitter is properly neutralized. Tighten the nuts to hold the capacitor plates in place.

m. Pull out the TEST KEY, install modulator tubes V7 and V8 (fig. 19), and connect plug P1807 to receptacle J2 at the rear of the transmitter (fig. 16).

n. Make sure the white dot on the shaft of the ANTENNA LOADING control is in the 12 o'clock position. Turn the meter switch to FINAL AMP TOTAL, and press the TEST KEY.

o. Adjust the FINAL AMP PLATE tuning control for a minimum indication on the meter. Rotate the ANTENNA LOADING control counterclockwise until the meter indicates 180 milliamperes. Readjust the FINAL AMP PLATE tuning control for a minimum indication on the meter.

p. Turn the meter switch to FINAL AMP GRID. Alternately adjust the FINAL AMP GRID tuning control and the 2ND AMP PLATE tuning control until a maximum indication is obtained on the meter. Set the EXCITATION CONTROL for a meter indication of 10 milliamperes.

***Caution:* When adjusting the transmitter for 50 watt output (*q* below), do not exceed a final amplifier total current of 220 milliamperes.**

q. Turn the meter switch to FINAL AMP TOTAL. Rotate the ANTENNA LOADING control counterclockwise until the wattmeter connected to receptacle J1802 (*c* above) indicates 50 watts power output. If it is not possible to obtain a power output of 50 watts, it may be necessary to reposition output loop L8 (fig. 19). Tight coupling between tank coil L7 and output loop L8 results in heavier loading and higher final amplifier total current. Loose coupling has the opposite effect.

r. Pull out the TEST KEY and dial 10 to turn the equipment off.

s. Set the multimeter to the 250-volt scale and the FUNCTION switch to DIRECT. Connect the negative lead to the adjustable slide on resistor R5 in the PP–1331/FRN–20 (fig. 242), and the positive lead to the chassis.

t. Dial 9. The multimeter will indicate −100 volts (par. 38*a*).

u. Press the TEST KEY. The multimeter should indicate −25 volts on the 50-volt range of the multimeter.

v. If the multimeter does not indicate −25 volts when the TEST KEY is pressed, dial 10 and pull out the TEST KEY. Move the slide slightly on resistor R5. Set the multimeter to the 250-volt range.

w. Repeat the procedure given in *t*, *u*, and *v* above until the multimeter indicates −25 volts when the TEST KEY is pressed. Dial 10 and pull out the TEST KEY.

x. Disconnect the multimeter leads from R5, remove the interlock jumper plug from interlock switch S1, and replace the front panel.

y. Disconnect the wattmeter test cable from receptacle J1802 (fig. 16). Reconnect the RF cable to receptacle J1802 as shown in the figure.

40. Adjustment of Regulated Supply for Electrical Goniometer Motor GO–12/FRN–20

Note. The regulated supply for the motor of the No. 1 goniometer consists of the No. 1 O–371/FRN–20, the No. 1 AM–1246/FRN–20, and the SB–830/FRN–22A in the CY–2274/FRN–22A and the No. 1 PP–1329/FRN–20 in the No. 1 CY–1899/FRN–22 (fig. 2, TM 11–5825–205–12).

a. Open the rear door of the CY–2274/FRN–22A and insert thermal relay K902 in the O–371/FRN–20 (fig. 22). Be sure to close the door tightly.

b. Locations of the controls and meters on the meter panel are shown in figure 232. Turn the LINE switch to the EQUIPMENT NO. 1 position. Turn the CURRENT switch to the EQUIPMENT NO. 1 AMP TOTAL position.

c. Dial 9, then 8. When 8 is dialed, the No. 1 transmitting equipment is placed on the air. The motor on the goniometer will start and operate on voltage supplied by the powerline. The powerline frequency and voltage will be indicated on the FREQUENCY and VOLTS meters. After approximately 60 seconds time delay, thermal relay K902 (fig. 22) will operate. The input to the goniometer motor is then connected to the output of the regulated supply instead of to the powerline. The CURRENT meter may give a small indication, but the FREQUENCY and VOLTS meters may give no indication, because the LEVEL and OSC FREQUENCY controls are probably turned to the maximum counterclockwise positions.

***Caution:* If the goniometer motor does not start before the VOLTS meter (*d* below) indicates 135 volts or the amplifier total current on CURRENT meter is 225 milliamperes, turn the LEVEL control fully counterclockwise and refer to the performance chart (par. 228*c*).**

d. The control locations on the O–371/FRN–20 and AM–1246/FRN–20 are shown in figures 37 and 38 respectively. Slowly rotate the LEVEL control on the AM–1246/FRN–20 clockwise until the VOLTS meter reads 110–120 volts. The VOLTS meter may show a fluctuation between the voltage at which the goniometer motor starts (70–90 volts) and the voltage at which the motor reaches synchronous speed (90–100 volts). When synchronous speed is obtained, the fluctuation in the voltage will stop.

e. If the frequency of the main ac power supplied to the shelter is 60 cycles, adjust the OSC FREQUENCY control on the O–371/FRN–20 until the FREQUENCY meter indicates 50 cycles. If the frequency of the main ac power is 50 cycles, adjust the OSC FREQUENCY control until the FREQUENCY meter indicates 60 cycles. The reason for this procedure is given in chapter 2.

f. Readjust the LEVEL control for a 135-volt reading on the VOLTS meter.

g. Rotate the REGULATOR control on the O–371/FRN–20 until the VOLTS meter indicates 115 volts.

h. Allow the equipment to operate for a few minutes. Check the frequency of the O–371/FRN–20 as indicated by the FREQUENCY meter. If necessary, readjust the OSC FREQUENCY control until the frequency determined to be correct in *e* above is indicated.

i. Rotate the OVERLOAD CONTROL on the AM–1246/FRN–20 counterclockwise until overload relay S2 (fig. 207) begins to chatter. Then slowly rotate the OVERLOAD CONTROL clockwise until the chatter stops.

j. Dial 10 to turn off the equipment.

k. Dial 9, then 8 to turn the equipment on. When the goniometer motor circuit is transferred to the output of the PP–1329/FRN–20, overload relay S2 should not chatter if the OVERLOAD CONTROL is properly adjusted.

l. If overload relay S2 does chatter, rotate the OVERLOAD CONTROL farther clockwise. Then dial the equipment off and on several times. If necessary, continue to rotate the OVERLOAD CONTROL farther clockwise until overload relay S2 does not chatter when the goniometer motor circuit is transferred to the output of the PP–1329/FRN–20.

m. Dial 10 to turn off the equipment.

41. Selection of Goniometer Motor Pulley

(fig. 30)

Two motor pulleys are shipped with each goniometer. One pulley is installed on the goniometer motor shaft, and the other one is taped to the housing for the frequency modulation (fm) and goniometer capacitors. The 2⅝-inch diameter pulley must be used when the goniometer motor is to be operated on 60-cycle power. The 3⅛-inch diameter pulley must be used when the motor is to be operated on 50-cycle power. *Since the operating power for the goniometer motor is obtained from the regulated supply, it is the output frequency of this supply that determines which pulley to use; not the frequency of the main powerline.* Paragraph 40*e* gives directions for determining the output frequency of the regulated supply. If it is necessary to change pulleys to match the output of the regulated supply, follow the procedure outlined below.

a. Loosen the motor base mounting bolts. Remove the drive belt from the motor pulley.

b. Use a No. 10 setscrew wrench to loosen the setscrews on the motor pulley. Remove the pulley from the motor shaft.

c. Install the correct pulley on the motor shaft, replace and aline the drive belt, and tighten the pulley setscrews.

d. Position the motor so that there is 1 inch of vertical play in the drive belt. Tighten the motor base mounting bolts.

***Caution:* To prevent excessive drive belt wear, the drive belt and motor pulley must be carefully alined so that, as the goniometer**

motor operates (*e* below), the drive belt will remain centered on the motor pulley and not rub against the face of either pulley flange.

e. Dial 9, then 8. Observe the drive belt as the goniometer motor operates.

f. If the drive belt does not remain centered on the motor pulley, dial 10. Reposition the goniometer motor slightly.

g. Repeat the procedure given in *e* and *f* above until the drive belt is properly alined. After the belt is alined, dial 10.

42. Adjustment of Keyer KY–175/FRN

(fig. 33)

The keyer uses two segmented wheels for repetition rate and transmission of the call letters for the omnirange set. Code wheel W1 contains the call letters and cycle wheel W2 controls the repetition rate of the call letters. Since the call letters are different for each omnirange set, it will be necessary to break out segments in the circumference of both of these wheels to provide the required call letters and repetition rate. Instructions for making the breakouts are given in *a* through *r* below.

a. Two knurled thumbscrews hold the dust cover at the rear of the keyer. Loosen the thumbscrews and remove the dust cover.

b. Remove the ½–20 nut, washer, and reinforcing plate which hold code wheel W1 in place. Remove the code wheel.

c. Since there are 100 segments around the circumference of the code wheel, the total segments used for the call letters must be less than this number. Calculate the number of segments required for the call letters based on the following data:

(1) Break out three segments for a dot.
(2) Break out seven segments for a dash.
(3) Leave one segment between the dots and/or dashes.
(4) Leave five segments between letters.

d. An example of code wheel breakouts is shown in figure 45. Note that the code wheel rotates clockwise, and that the call letters must be broken out counterclockwise around the circumference of the wheel. Use a pair of long-nosed pliers to make the correct number of breakouts on the code wheel to correspond to the call letters of the omnirange set.

e. Replace the code wheel on the shaft so that the call letters are broken out counterclockwise as viewed from the rear of the keyer. Be sure the positioning pin is properly seated. Replace the reinforcing plate, washer, and nut. Tighten the nut securely.

f. Before making breakouts in cycle wheel W2, it is necessary to determine the desired repetition rate for the call letters. Figure 45 shows the breakouts necessary for transmitting the call letters once for each revolution of the cycle wheel. One revolution of cycle wheel W2 requires 100 seconds when the keyer motor is operated on 60-cycle ac power and 120 seconds when the motor is operated on 50-cycle ac power. If a second breakout like the one shown in figure 45 is made on the opposite side of the cycle wheel, the call letters will be transmitted twice during each revolution. Three additional examples of cycle wheel breakouts are shown in figure 46. The repetition rate is indicated for each example.

g. Remove the ac plug from receptacle J501 on the keyer (fig. 16).

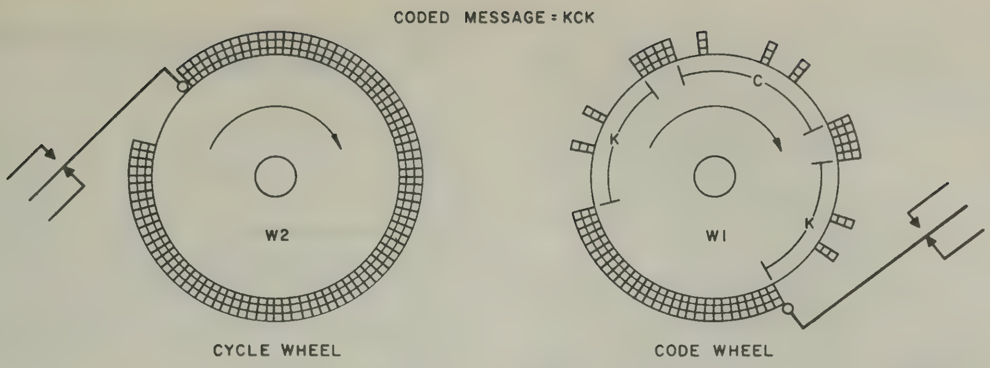
h. Dial 9. The operation of the keyer motor can now be controlled by intermittently inserting the ac plug into receptacle J501.

i. Let the motor operate until the contact roller on code wheel W1 is just ready to drop into the first breakout as shown in figure 45. Remove the plug from J501.

j. Remove the ½–20 nut, washer, and reinforcing plate from cycle wheel W2. If the contact roller is not seated exactly in the center of one of the segments on the circumference of cycle wheel W2, lift the roller and remove the cycle wheel. Turn the cycle wheel over and replace it on the shaft so that the contact roller can be brought more nearly to the center of a segment. Leave the cycle wheel in the position giving the best alinement.

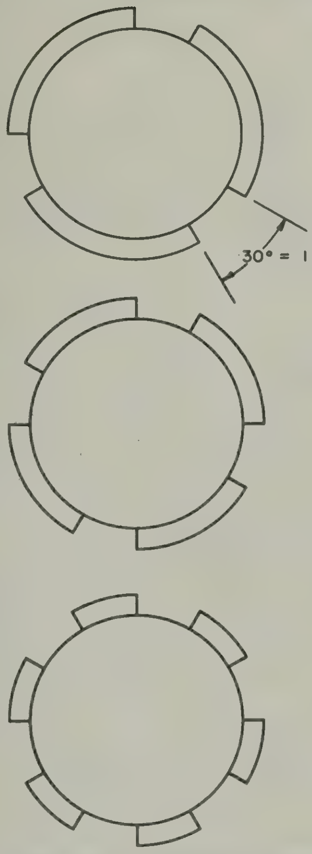
k. Mark the cycle wheel segment on which the contact roller rests. Operate the keyer motor until the code wheel contact roller has just lifted out of the last breakout in the last letter of the call letters. On the cycle wheel, mark the segment on which the contact roller is now resting. Do not remove any segments until instructed to do so later. When the two marked segments and the segments in between are removed, the cycle wheel contacts will remain closed for the complete transmission of the call letters.

Note. Do not reverse the cycle wheel on the shaft after the location of the first breakout has been marked.



ROLLERS POSITIONED FOR START OF MESSAGE.

Figure 45. Alinement of code and cycle wheels, with typical breakouts.



3 BREAKOUTS ON CYCLE WHEEL REPEATS MESSAGE EVERY 33 1/3 SECONDS (60 CYCLE), EVERY 40 SECONDS (50 CYCLE).

4 BREAKOUTS ON CYCLE WHEEL REPEATS MESSAGE EVERY 25 SECONDS (60 CYCLE), EVERY 30 SECONDS (50 CYCLE).

6 BREAKOUTS ON CYCLE WHEEL REPEATS MESSAGE EVERY 16 2/3 SECONDS (60 CYCLE), EVERY 20 SECONDS (50 CYCLE).

CYCLE WHEEL REMOVED, CONTACTS JUMPERED, REPEATS MESSAGE EVERY 8 1/3 SECONDS (60 CYCLE), EVERY 10 SECONDS (50 CYCLE).

POWER LINE FREQUENCY	CODE SPEED	CODE WHEEL SPEED	CYCLE WHEEL SPEED	CODE MESSAGE CYCLE
60	7.5 WPM	7.2 RPM	0.6 RPM	8 1/3 SEC
50	6.25 WPM	6 RPM	0.5 RPM	10 SEC

WPM = DENOTES WORDS PER MINUTE.

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Figure 46. Data for cycle wheel breakouts.

l. Keep in mind the repetition rate desired, and mark the remaining portion of the circumference of the cycle wheel in the manner described in *i* and *k* above.

Caution: **The breakouts in the cycle wheel should be just long enough for the code wheel to complete its call letters. Thus, at the maximum, no more than nine segments should be removed for each breakout (*m* below). Removal of more than nine segments will allow the code wheel to repeat the first portion of the call letters.**

m. When all cycle wheel breakouts have been marked, let the cycle wheel rotate several times to double check the markings. Then remove the cycle wheel and make the breakouts indicated.

n. Replace the cycle wheel on the shaft. Be sure the positioning pin is properly seated. Replace the reinforcing plate, washer, and nut. Tighten the nut securely.

o. Allow the cycle wheel to rotate several times to see that the breakouts are correct. A spline-type setscrew wrench is held by a clip near the cycle wheel. If a slight adjustment is necessary, use this wrench to loosen the cycle wheel hub so that the wheel can be repositioned.

p. Dial 10.

q. Insert the ac plug into receptacle J501 on the keyer (fig. 16).

r. Replace the dust cover at the rear of the keyer chassis.

43. Tuning Adjustment on Antenna Group AN/FRA–14

(fig. 27)

***Warning:* The 115 volts ac supplied to this equipment is present on the terminals of receptacle J1. Be careful not to come into contact with these terminals after the bottom plate is removed.**

a. Remove the four screws and lockwashers that hold the bottom plate in place and let it hang free as shown in the figure. *Do not* disconnect the cables attached to receptacle J1 and J2.

b. Use the multimeter to measure the output. Set the FUNCTION switch to the DIRECT position and use the 2.5-volt range. Connect the positive lead to the center terminal of receptacle J1. Connect the negative lead to one of the receptacle mounting screws.

c. Dial 9 then 8.

d. Adjust capacitor C1 for a maximum direct current (dc) voltage indication on the multimeter.

e. Dial 10 to turn the equipment off.

f. Disconnect the multimeter from receptacle J2.

g. Hold the bottom plate in position; be sure that the rubber gasket is properly seated to provide a good weather seal, and fasten the plate in place with the four screws and lockwashers.

44. Adjustment of Audio Frequency Amplifier AM–1247/FRN–20

(fig. 26)

a. The AM–1247/FRN–20 and the remote control unit are mounted in the remote control cabinet (fig. 4, TM 11–5825–205–12). Input and output connections for the AM–1247/FRN–20 are made through terminal board E501 on the rear of the remote control unit (fig. 16).

b. Remove V5 (fig. 26) from the AM–1247/FRN–20.

c. Connect a 500-ohm, 2-watt dummy load resistor (par. 31*c*) between terminals 5 and 6 on terminal board E501 on the rear of the remote control unit.

d. Connect the output from the audio oscillator (par. 25*b*) to terminals 3 and 4 on terminal board E501. Following the instructions given in TM 11–2684A and set the controls on the audio oscillator to obtain a 1.75-millivolt, 1,000-cycle output.

e. Use the vacuum-tube voltmeter (vtvm) to measure the output of the AM–1247/FRN–20 across the dummy load resistor. Follow the instructions given in TM 11–5511. Set the SELECTOR switch to the AC position and the RANGE switch to the 3V range. Connect the vtvm leads across the dummy load resistor or to terminals 5 and 6 of E501.

f. Connect the power cable from the remote control cabinet (fig. 4, TM 11–5825–205–12) to a 115-volt ac power source.

g. Adjust R1 to obtain an output level indication on the vtvm of 2.45 volts ac (3 decibels (db)).

h. Replace tube V5 in its socket. Allow sufficient time for the tube to warm up.

i. Adjust R16 for a 1.73-volt (0 db) indication on the vtvm.

j. Disconnect the power cable from the 115-volt ac source.

k. Disconnect the vtvm leads from terminals 5 and 6 of E501.

l. Disconnect the dummy load resistor from terminals 5 and 6 of E501.

m. Disconnect the audio oscillator from terminal board E501.

45. Modulation Adjustments of Radio Transmitter T–573/FRN–20

a. Test Equipment Connections.

(1) The oscilloscope test cable terminates at

one end in a UG–21D/U plug (par. 31*c*). Remove enough insulation from the opposite end of the cable to permit the shield braid and center conductor to be connected to screw terminals or solder terminals.

(2) Connect the plug end of the test cable to the CARRIER TEST OUT receptacle on the transmitter (fig. 36).

(3) Connect the opposite end of the test cable to the vertical plate terminals on the oscilloscope. To make this connection, follow the instructions contained in the technical manual for the oscilloscope. *Make certain that the vertical plates of the cathode-ray tube are disconnected from the vertical amplifier in the oscilloscope.*

(4) Connect the oscilloscope power cable to one of the convenience outlets on the antenna pedestal (fig. 3, TM 11–5825–205–12). Be sure that circuit breaker K1007 (fig. 201) is in the ON position.

b. Voice Modulation Adjustment.

(1) Terminal board E501 is located at the rear of the remote control unit (fig. 16). Connect the output from the audio oscillator and the multimeter across terminals 3 and 4 on E501. Set the controls on the audio oscillator to obtain a 1.75-millivolt, 1,000-cycle output.

(2) Connect the power cable from the C–1739/FRN–20 and the AM–1247/FRN–20 in the remote control cabinet to a 115-volt ac power source.

(3) Set the ALARM SELECTOR on the remote control unit in the down position. Notify the operator at the remote point to listen for the buzzer. When 9 is dialed as indicated in (5) below, the buzzer in the remote control unit will sound. When the buzzer sounds, the operator is to set the ALARM SELECTOR switch to the center position to silence the buzzer, wait for a signal from the omnirange site which will be indicated by the buzzer sounding intermittently, and then listen to the handset.

(4) Use the vtvm to measure the audio signal input to the transmitter. Set the SELECTOR switch to the AC position and the RANGE switch to the 1V range. Connect the positive lead to terminal 3 on TB1 and the common lead to terminal 6 on TB1 on the PP–1331/FRN–20 (fig. 6).

(5) On the CY–1738/FRN–20, dial 9 and set the LOCAL-REMOTE switch to the REMOTE position.

(6) Signal the operator at the remote point (par. 36*q*).

(7) Tell the operator to press the press-to-talk bar on the microphone at the remote point and use the clamp on the microphone stand to hold down the press-to-talk bar. Tell the operator to release the microphone press-to-talk bar after 10 minutes have elapsed.

Note. When the press-to-talk bar on the microphone is pressed, the transmitter is keyed and the operator cannot be signaled, until the press-to-talk bar is released. If the voice modulation adjustment is not completed before the operator releases the press-to-talk bar, request the operator to again clamp the press-to-talk bar down for whatever period is considered necessary.

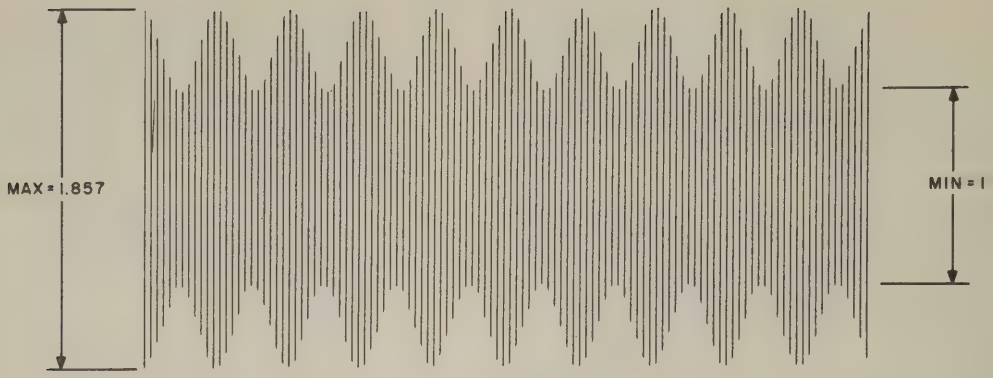
(8) Adjust IDENTIFICATION LEVEL control R17 on the goniometer (fig. 30) for an indication of 0.3 volt on the vtvm connected to terminal board TB1 on the PP–1331/FRN–20 ((4) above).

(9) Disconnect the vtvm leads.

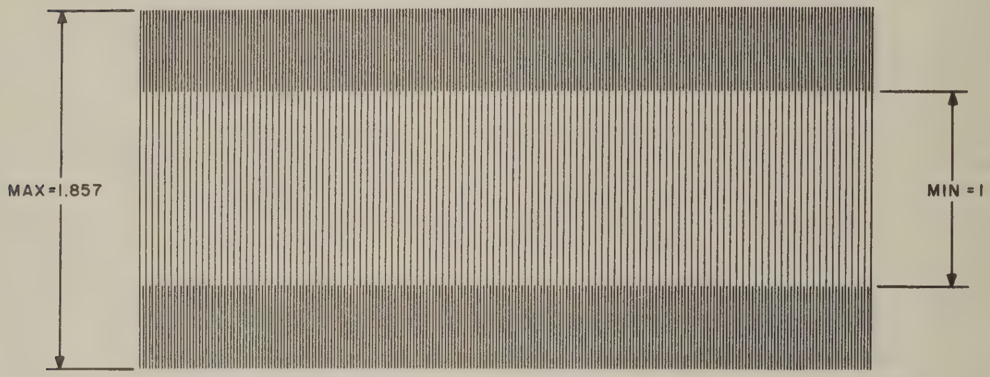
(10) On the oscilloscope, set the SYNC SELECTOR to INT and the X SELECTOR to RECUR SWEEP. Adjust the SWEEP RANGE and SWEEP VERNIER controls, during the MODULATION GAIN control adjustment given in (11) below, to display the modulated transmitter carrier.

(11) Adjust the MODULATION GAIN control in the transmitter (fig. 36) to obtain 30 ±2 percent modulation of the transmitter carrier. The correct ratio for a 30 percent modulation level is shown in A, figure 47.

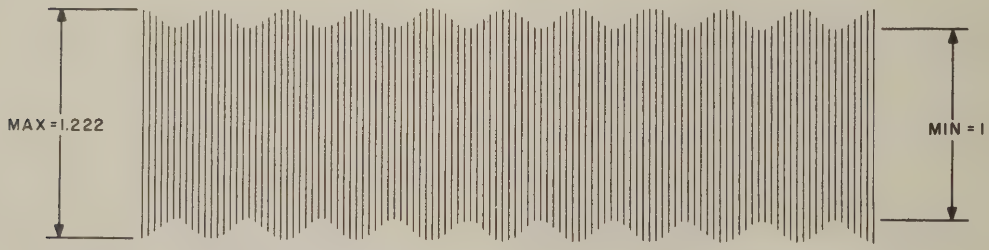
Note. If the oscilloscope pattern is not large enough to observe the modulation level, disconnect the test cable from the oscilloscope. Cut off about 3 inches of the test cable, reconnect the cable, and recheck the modulation pattern. If necessary, continue to reduce the length of the test cable about 3 inches at a



A. VOICE MODULATION OF 30 PER CENT.



B. SUBCARRIER MODULATION OF 30 PER CENT.



C. IDENTIFICATION TONE MODULATION OF 10 PER CENT.

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Fig. 47. Oscilloscope modulation patterns.

time until a satisfactory modulation pattern can be observed on the oscilloscope.

(12) Signal the operator and notify him that the voice modulation adjustment is completed. Tell him to expect the buzzer to sound when 10 is dialed as indicated in (13) below and, when this occurs, to set the ALARM SELECTOR to the down position to silence the buzzer.

(13) On the C–1738/FRN–20, set the LOCAL-REMOTE switch to the LOCAL position and dial 10.

(14) At the remote control point, disconnect the power cable on the remote control cabinet from the 115-volt ac source.

(15) At the remote control point, disconnect the audio oscillator from terminal board E501.

c. Subcarrier Modulation Adjustments.

(1) Remove the ac plug from receptacle J1 on the O–373/FRN (fig. 16). This will prevent the output of the O–373/FRN from modulating the transmitter carrier during the subcarrier modulation adjustment.

(2) Dial 9, then 8.

(3) Wait for the goniometer motor to be changed over to the output of the regulated supply. Adjust SUB-CARRIER LEVEL control R18 on the goniometer (fig. 30) for 30 ±2 percent modulation of the transmitter carrier. The correct ratio for a 30 percent modulation level is shown in B, figure 47.

(4) Dial 10.

(5) Reconnect the ac plug to receptacle J1 on the O–373/FRN.

d. Identification (Keyed Tone) Modulation Adjustment.

(1) Disconnect plug P1801 from receptacle J1 on the goniometer (fig. 16). This will remove the subcarrier modulation while the identification modulation adjustment is being made.

(2) Dial 9, then 8.

(3) Remove the dust cover from the rear of the keyer (fig. 33).

(4) Observe the code and cycle wheels on the keyer (fig. 33). When the contact rollers on both wheels are in the broken out portions, remove the ac plug from receptacle J501 on the keyer (fig. 16). This will stop the keyer motor during the portion of the cycle when the identification tone is being transmitted.

(5) Adjust R15 on the O–373/FRN (fig. 25) for approximately 10 percent modulation of the transmitter carrier. The correct ratio for a 10 percent modulation level is shown in C, figure 47.

(6) Dial 10.

(7) Replace the dust cover on the rear of the keyer and insert the ac plug into receptacle J501.

(8) Reconnect plug P1801 to receptacle J1 on the goniometer.

(9) Disconnect the oscilloscope test cable from the CARRIER TEST OUT receptacle on the transmitter.

46. Variable Carrier Modulation Adjustment

(fig. 32)

a. Set the ON-OFF switch on the monitor to the ON position. Allow sufficient time for the monitor to warm up before proceeding to *b* below. *Disregard any alarm indications on the monitor on the fact that the pointer on the monitor COURSE RELAY meter may be off-scale.*

b. Dial 9, then 8.

c. Turn the monitor LEVEL switch to the VAR position.

Warning: **Dangerous voltages exist at several points within the cabinet which houses the modulation eliminator. Be careful when adjusting capacitor C7 (*d below*). Use an insulated screwdriver and be especially careful not to touch the plate caps of the 829B tube (V4) in the transmitter.**

d. Adjust C7 on the modulation eliminator (fig. 18) for maximum variable carrier level as indicated on the monitor LEVEL METER.

e. The rotor of C7 is visible through vent holes in the shield cover shown in figure 18. Note the position of the rotor. If C7 is set at either maximum or minimum capacity, it will be necessary to perform the procedures given in *f* through *h* below. If C7 is set to some point between maximum and minimum capacity, follow directions given in *i* below.

f. Dial 10. Remove the shield cover which incloses inductor L3.

g. If C7 was at *maximum capacity* in the test made in *e* above, squeeze the turns of inductor L3 (fig. 18) *closer together.* If capacitor C7 was at *minimum capacity, spread* the turns of inductance L3 *farther apart.*

h. Replace the shield cover and repeat the procedures given in *b* through *e* above until capacitor C7 can be adjusted for maximum indication on the monitor LEVEL METER with a setting between maximum and minimum capacity.

i. Dial 10. Set the monitor ON-OFF switch to the OFF position.

j. Disconnect plug P9 from receptacle J1 on the monitor (fig. 16).

k. Dial 9, then 8. Use the vtvm to measure the contact potential at the cathode of tube V1 in the AN/FRA–14 (fig. 27). Follow the instructions contained in the technical manual for the vtvm. Set the SELECTOR switch to the + (plus) position and the RANGE switch to the 2V range. Connect the positive vtvm lead to the center conductor of plug P9. Connect the common lead to the plug body. The vtvm should give an indication of about 0.1 to 0.2 volt. Dial 10.

l. Remove plug P1803 from receptacle J6 on the goniometer (fig. 16).

m. Dial 9, then 8.

n. Rotate the azimuth plate (fig. 30) on the goniometer through 360° and, at the same time, note the maximum and minimum indications on the vtvm connected to plug P9. Subtract the contact potential measured in *k* above from both the maximum and minimum voltages. Compute the ratio of the two resulting voltages.

o. When the proper relationship exists between the maximum and minimum voltages, the ratio will be 1.857 to 1. If the ratio is not 1.857 to 1, rotate the SIDE BAND LEVEL control (fig. 31) on the modulation eliminator a small amount in either direction.

p. Repeat procedures given in *n* and *o* above until a ratio of 1.857 to 1 is obtained. With this ratio, the variable carrier modulation will be 30 ±2 percent.

Note. Since typical indications on the meter in each modulation eliminator are affected by the setting of the SIDE BAND LEVEL control, these indications should be taken at this time and kept for future reference. Note the meter indication for each position of the meter switch. Record these indications, by switch position, on a small tag. Attach the tag to one of the knurled thumbscrews on the front panel of the modulation eliminator.

q. Dial 10. Disconnect the vtvm from plug P9.

r. Reconnect plug P9 to receptacle J1 on the monitor.

s. Reconnect plug P1803 to receptacle J6 on the goniometer.

47. Adjustment of Transmitting Equipment No. 2

(fig. 2, TM 11-5825-205-12)

The No. 2 transmitting equipment consists of the following: all CY-1899/FRN-22 components; the O-371/FRN-20 and the AM-1246/FRN-20 in the CY-2274/FRN-22A; and the O-373/FRN and the keyer in the CY-1897/FRN-22.

a. Use the adjustment procedures for transmitting equipment No. 1 (pars. 37-46) to adjust transmitting equipment No. 2, with the following exceptions:

b. Set circuit breaker K1012 on the antenna pedestal (fig. 201) to the ON position.

***Warning:* When circuit breaker K1012 is in the ON position, dangerous voltages will exist within the No. 2 cabinet CY-1899/FRN-22. Be careful when making adjustments. Use properly insulated tools and avoid touching exposed terminals, contacts, or other potential sources of high voltage.**

c. Exclude instructions in paragraphs 43 and 44.

d. Dial 7 for 9.

e. Dial 6 for 8.

48. Adjustment of Course Monitor MX-1837/FRN-20

The procedure for adjustment of the monitor is outlined in paragraphs 49 through 55. Complete the procedures given in *a* through *d* below before starting the adjustment procedure.

***Caution: Do not* attempt to use the adjustment screw to zero the COURSE RELAY meter when the pointer is off scale against the stops on either side. Turn the monitor ON-OFF switch (fig. 32) to the ON position for a few seconds. When the monitor is turned on, fingers within the meter will bring the pointer to a zero or near zero position. Turn the monitor ON-OFF switch to the OFF position. If the pointer is not quite at zero, use the adjustment screw to bring it to zero.**

a. Observe the COURSE INDICATOR meter and the LEVEL METER. If necessary, zero the pointers on these meters with their adjustment screws.

b. Set the monitor ON-OFF switch to the ON position. The green pilot lamp, designated POWER, and the three red pilot lamps, designated ALARMS, will light. Allow sufficient time for the monitor to warm up before performing *c* below.

c. Dial 9, then 8.

d. Set NORMAL-CAL switch S5 (fig. 220) to the NORMAL position.

49. Course Monitor MX–1837/FRN–20 Level Adjustments

a. Input Level.

(1) Set the LEVEL switch to the INPUT position.

(2) Remove rectifier V10 from its socket (fig. 24).

(3) Adjust METER BAL control R106 until the LEVEL METER indicates zero. This balances the diode contact potentials of V14.

(4) Replace V10.

(5) Use the vtvm to measure the input level voltage. Set the SELECTOR switch to the AC position and the RANGE switch to the 2V range. Connect the positive vtvm lead to the front right-hand terminal of INPUT LEVEL control R1 (fig. 48). Connect the common vtvm lead to the chassis.

(6) Adjust R1 to obtain an indication of 0.2 volt on the vtvm.

(7) With the vtvm still connected, adjust R107 for an indication of 100 percent on the LEVEL METER.

(8) Disconnect the vtvm and readjust R1 until the LEVEL METER indicates 100 percent. This step compensates for the loading effect of the vtvm.

b. Reference Level.

(1) Set the LEVEL switch to the REF position.

(2) Use the vtvm to measure the reference level voltage. Set the SELECTOR switch to the AC position and the RANGE switch to the 4V range. Connect the positive vtvm lead to the center tap of REF LEVEL control R5. Connect the common vtvm lead to the chassis.

(3) Adjust R5 to obtain an indication of 1 volt on the vtvm.

(4) With the vtvm still connected, adjust REF CAL control R6 for an indication of 100 percent on the LEVEL METER.

(5) Disconnect the vtvm and readjust R5 until the LEVEL METER indicates 100 percent. This step compensates for the loading effect of the vtvm.

c. Variable Level.

(1) Set the LEVEL switch (fig. 32) to the VAR position.

(2) Use the vtvm to measure the variable level voltage. Set the SELECTOR switch to the AC position and the RANGE switch to the 4V range. Connect the positive vtvm lead to the center tap of VAR LEVEL control R47 (fig. 48). Connect the common vtvm lead to chassis ground.

(3) Adjust R47 to obtain an indication of 1.75 volts on the vtvm.

(4) With the vtvm still connected, adjust VAR CAL control R48 for an indication of 100 percent on the LEVEL METER.

(5) Disconnect the vtvm and readjust R47 until the LEVEL METER indicates 100 percent. This step compensates for the loading effect of the vtvm.

50. Reference Carrier Filter Adjustment

(fig. 48)

Capacitor C2, the reference carrier filter adjustment, has been correctly set at the factory. No further adjustment will be necessary.

51. Reference Carrier FM Detector Adjustment

(fig. 48)

a. Use the vtvm to measure the voltage at the primary (terminals 1 and 2) of transformer T2. Set the SELECTOR switch to the AC position and the RANGE switch to the 100V range. Connect the vtvm leads between terminal 2 of transformer T2 and chassis ground. Record the indication obtained on the vtvm.

b. Without changing the vtvm control settings, disconnect the vtvm from transformer T2 and connect the vtvm leads to terminal 2 of transformer T1 and chassis ground.

c. Connect the oscilloscope vertical input terminals to terminal 2 of transformer T1 and chassis ground. Adjust the oscilloscope controls to display a 30-cycle sine wave.

d. Adjust capacitor C10 to obtain an oscilloscope pattern of a good 30-cycle sine wave with maximum amplitude. When such a pattern is obtained, the voltage on the primary of transformer T1 should be approximately two to three

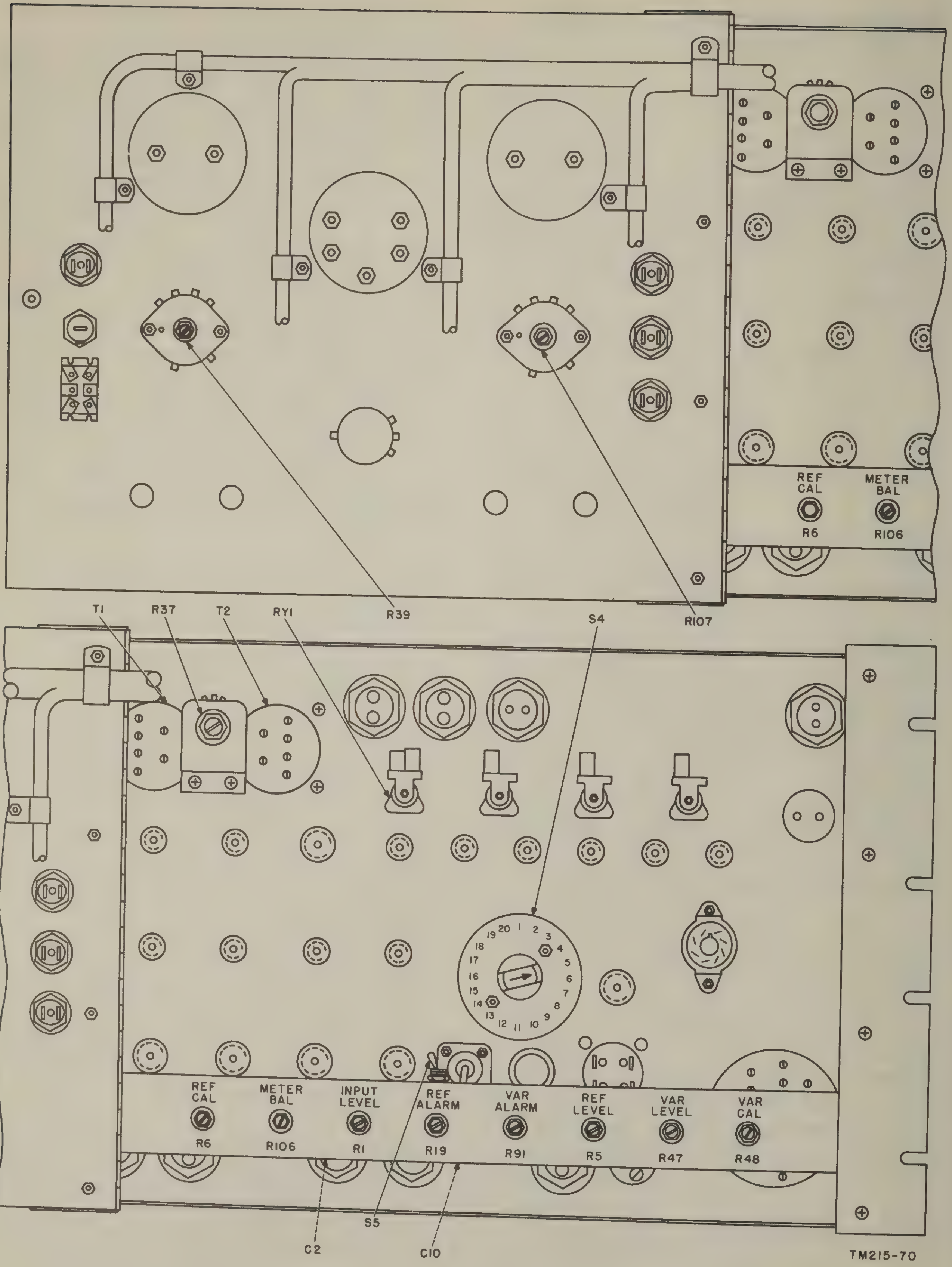


Figure 48. Course Monitor MX-1837/FRN-20, interior view, control locations.

times the voltage on the primary of transformer T2, usually 50 to 80 volts ac.

e. Disconnect the oscilloscope and the vtvm.

52. Phase Selector Adjustment

(figs. 32 and 48)

a. Rotate phase selector switch S4 clockwise, one position at a time, until the COURSE INDICATOR meter and the COURSE RELAY meter indicate a near zero (balanced) reading.

b. Loosen the dial lock on the PHASE ZERO control and rotate the PHASE ZERO control for an exact zero indication on the COURSE INDICATOR and COURSE RELAY meters. Balanced conditions will occur at 0° to 180° from the bearing of the AN/FRA–14. At 0°, clockwise rotation of the PHASE ZERO control will cause the pointers on the COURSE INDICATOR and COURSE RELAY meters to move to the right. Counterclockwise rotation of the PHASE ZERO control will cause the pointers to move to the left. If the direction of movement of the meter pointers does not correspond to the direction of the rotation of the PHASE ZERO control, rotate S4 180° and readjust the PHASE ZERO control for a zero indication on the COURSE INDICATOR and COURSE RELAY meters. Further rotation of the PHASE ZERO control in either direction should cause the meter pointers to move in the corresponding direction.

c. Be sure that the PHASE ZERO control is set for a zero indication on the meters. Tighten the dial lock.

53. Phase Comparator Balance Adjustment

(figs. 32 and 48)

a. Hold the TEST switch in the REF position, and adjust R37 for a zero indication on the COURSE INDICATOR and COURSE RELAY meters.

b. Hold relay RY1 in the energized position and turn the TEST switch to the VAR position. The COURSE INDICATOR and COURSE RELAY meters should still indicate zero. If the meters do not indicate zero, repeat the phase selector adjustment procedure (par. 52), then repeat the procedures given in this paragraph until as near a balanced condition as possible is obtained between the REF and VAR positions of the TEST switch. Adjust R37 to divide any remaining unbalance *equally* between the REF and VAR positions of the TEST switch.

Note. Because of its effect on subsequent adjustments, take special care when adjusting R37 to divide any unbalance *equally.*

54. Calibration Check

(figs. 32 and 48)

a. Set the LEVEL switch to the VAR position.

b. Set NORMAL-CAL switch to the CAL position.

c. Adjust VAR LEVEL control R47 for an indication of 100 percent on the LEVEL METER.

d. Record the numbered position of phase selector switch S4 and the dial reading of the PHASE ZERO control on a tag.

e. Turn S4 to the position which most nearly gives a zero indication on the COURSE RELAY meter. Adjust the PHASE ZERO control until an exact zero indication is obtained.

f. Record the present numbered position of S4 and the dial reading on the PHASE ZERO control on the same tag as directed in *d* above. Be sure to identify the settings as *normal* and *calibrate*, corresponding to the position of NORMAL-CAL switch S5 when the settings were taken. Attach this tag to one of the front panel knobs on the monitor.

g. Return S5 to the NORMAL position, and readjust R47 for an indication of 100 percent on the LEVEL METER.

h. Return S4 and the PHASE ZERO control to the positions recorded in *d* above.

55. Monitor Alarm Adjustments

(figs. 35 and 61)

a. Reference Level Alarm.

Note. In this adjustment, disregard any COURSE alarms signal obtained as a result of the rotation of REF LEVEL control R5.

(1) Turn the LEVEL switch to the REV position.

(2) Adjust REF LEVEL control R5 until the LEVEL METER indicates the signal level at which it is desired to operate the alarm (80–85 percent is most frequently used for the alarm level).

(3) Adjust REF ALARM control R19 until the red REFERENCE pilot lamp lights. Turning R19 back from this setting will turn the pilot lamp off. Set R19 to a point at which the pilot lamp just lights.

(4) Increase the signal level by rotating REF LEVEL control R5. The REFERENCE pilot lamp will go out. Test the operating point of the reference level alarm by rotating R5 through the level set up in (2) above.

(5) Rotate R5 until the LEVEL METER indicates 100 percent.

b. Variable Level Alarm.

Note. In this adjustment, disregard any COURSE alarms signal obtained as a result of the rotation of the VAR LEVEL control R47.

(1) Turn the LEVEL switch to the VAR position.

(2) Adjust R47 until the LEVEL METER indicates the signal level at which it is desired to operate the alarm (80–85 percent is most frequently used for the alarm level).

(3) Slowly adjust the VAR ALARM control R91 until the red VARIABLE pilot lamp lights. Turning R91 back from this setting will turn the pilot lamp off. Set R91 to a point at which the pilot lamp lights.

(4) Increase the signal level by rotating R47. The VARIABLE pilot lamp will go out. Test the operating point of the variable level alarm by rotating R47 through the level set up in (2) above.

(5) Rotate R47 until the LEVEL METER indicates 100 percent.

c. Course Alarm.

Note. The COURSE INDICATOR and COURSE RELAY meters must indicate a zero phase balance before making this adjustment. If a zero phase balance is not indicated, repeat the phase selector adjustment procedure first (par. 49). On each goniometer, the manufacturer's serial plate is located on the chasis almost directly beneath the drive belt. Check the manufacturer's serial number on either goniometer (fig. 2, TM 11–5825–205–12). Goniometers which have a serial number of 614 or above (fig. 30) are adjusted as described below. When making adjustments to goniometers with serial numbers of 613 and below (fig. 30), disregard all references to the locking device for the degree indicator scale and use a screwdriver to adjust control H1.

(1) The No. 1 goniometer is located in the No. 1 CY–1899/FRN–22. The location of the degree indicator scale on the goniometer is shown in figure 30. Record the reading on the degree indicator scale as the starting point for the course alarm adjustment.

(2) The degree indicator scale is locked in place by a latch plate and spring-loaded latch arm. Raise the latch arm so that it clears the latch plate and rotate H1 clockwise until the degree indicator scale moves the number of *off-course* degrees at which it is desired to have the monitor indicate an alarm.

(3) Adjust R39 on the monitor until the COURSE RELAY meter needle moves. The red COURSE pilot lamp will light.

(4) Rotate H1 counterclockwise. This will cause the COURSE RELAY meter needle to return to zero and turn off the red COURSE pilot lamp.

(5) Raise the latch arm so that it clears the latch plate and continue the counterclockwise rotation until a point is reached an *equal* number of degrees on the opposite side of the original position recorded in (1) above. At this point, the COURSE RELAY meter should indicate on the opposite side and the red COURSE pilot lamp will light as before. Control R39 may require readjustment to get correct relay action at this point. If R39 is readjusted, it will be necessary to repeat the procedures given in *b*(2) through (5) above until the COURSE RELAY meter indicates an equal number of degrees on each side of the original position of the degree indicator scale.

(6) Use H1 to return the degree indicator to its original position so that the notch in the latch arm engages with the latch plate. On goniometers with locking devices, rotate H1 counterclockwise until a release in the tension on the control can be felt. The COURSE INDICATOR and COURSE RELAY meters should now indicate zero.

(7) Turn the monitor LEVEL switch to the REF position and, if necessary, readjust monitor REF LEVEL control R5 to

obtain an indication of 100 percent on the LEVEL METER.

Note. Some interlocking exists between R39 and R5. This interlocking is important only at the highest course sensitivity. When adjusting for a course sensitivity of 1° or less, the settings of R39 and R5 should be rechecked several times to obtain the desired operation.

(8) Dial 10. Leave the monitor ON-OFF switch in the ON position. This will permit the monitor to remain in a warmed up condition at all times, provided circuit breaker K1004 on the antenna pedestal is in the ON position.

56. Course Discrepancy Adjustment

The monitor has been adjusted for a COURSE RELAY meter indication of zero with transmitting equipment No. 1 in operation (par. 42). Operation of transmitting equipment No. 2 may cause the COURSE RELAY meter to show a deviation to the right or left of zero. In some cases, this deviation may be great enough to operate the course alarm. Perform the following steps to check and, if required, adjust for any course discrepancy:

a. Dial 7, then 6.

b. Observe the COURSE RELAY meter on the monitor (fig. 32). If the COURSE RELAY meter is at zero, proceed to *f* below. If the COURSE RELAY meter is not at zero, complete the procedures given in *c* and *f* below.

Note. On each goniometer, the manufacturer's serial plate is located on the chassis almost directly beneath the drive belt. Check the manufacturer's serial number on the No. 2 goniometer. Goniometers that have a serial number of 614 or above (fig. 30) are adjusted as described below. When making adjustments to goniometers with serial numbers of 613 and below (fig. 30), disregard all references to the locking device for the degree indicator scale and use a screwdriver to adjust control H1.

c. The No. 2 goniometer is located in the No. 2 CY-1899/FRN-22. The mechanical parts on the goniometer that are involved in making the course discrepancy adjustment are shown in figure 30. Raise the latch arm so that it clears the latch plate and rotate H1 to obtain a zero indication on the monitor COURSE RELAY meter. Usually a 1° to 3° change on the degree indicator scale will be sufficient to correct the course discrepancy.

d. Loosen the two screws that hold the latch plate in place. The slot in the latch plate permits the plate to be moved slightly in either direction. Move the latch plate in the proper direction so that the notch in the latch arm engages with the latch plate. Tighten the latch plate holding screws.

e. On goniometers with locking devices, rotate H1 counterclockwise until a release in the tension on the control can be felt.

f. Dial 10.

57. Level Discrepancy Adjustments

The monitor has been adjusted for 100 percent of normal levels on input, reference, and variable signals with transmitting equipment No. 1 in operation (par. 49). Operation of transmitting equipment No. 2 may result in level indications a few percent above or below those recorded for transmitting equipment No. 1. Perform the following steps, and, if required, adjust to correct any level discrepancy:

a. Dial 7, then 6.

b. Set the LEVEL switch on the monitor (fig. 32) to the INPUT position.

c. The No. 2 transmitter is located in the No. 2 CY-1899/FRN-22. Adjust the ANTENNA LOADING control on the transmitter (fig. 36) to obtain a reading of 100 percent on the monitor LEVEL METER, but *do not exceed a final amplifier total current of 220 milliamperes.* To obtain the 100 percent input level, it may be necessary to reposition output loop L8 on the transmitter as described in paragraph 39*q*.

d. Turn the LEVEL switch on the monitor to the REF position.

e. The No. 2 goniometer is located in the No. 2 CY-1899/FRN-22. Adjust SUB-CARRIER LEVEL control R18 on the goniometer (fig. 30) to obtain an indication of 100 percent on the monitor LEVEL METER.

f. Turn the LEVEL switch to the VAR position.

g. The No. 2 modulation eliminator is located in the No. 2 CY-1899/FRN-22. Adjust the SIDE BAND LEVEL control on the modulation eliminator (fig. 31) to obtain an indication of 100 percent on the monitor LEVEL METER.

h. Dial 10.

Note. The location of interlock switch S1801 in CY-1899/FRN-22 is shown in figure 226. Remove the interlock jumper plug from interlock switch S1801 in both cabinets. Be sure to close both rear doors.

58. Final Adjustments

a. Place transmitting equipment No. 1 in operation by first dialing 9, then 8. Allow transmitting equipment No. 1 to operate for 24 hours. At the end of this period, recheck the following adjustments: tuning adjustment on the transmitter (par. 39), modulation adjustments (pars. 45 and 46), and alarm adjustments on the monitor (par. 55).

b. Place transmitting equipment No. 2 in operation by first dialing 7, then 6. Allow transmitting equipment No. 2 to operate for 24 hours and, at the end of this period, recheck the following adjustments: tuning adjustments on the transmitter (par. 39), modulation adjustments (pars. 45 and 46), course discrepancy adjustment (par. 56), and the level discrepancy adjustments (par. 57).

c. After final adjustments have been completed, a station log should be initiated. Record the initial meter indications on both transmitting equipments and the monitor. Keep other maintenance and repair data of value in this station log.

59. Flight Check of Omnirange Set

a. After final adjustments have been completed (par. 58), it will be necessary to make a flight check of the omnirange set with each transmitting equipment in operation. Only qualified personnel who are familiar with omnirange flight check procedures should make this check. The purpose of the flight check is to determine whether any further adjustment is required in modulation levels and/or course alinement. Some means of communication should be provided to permit the pilot to talk to personnel at the omnirange site while the flight check is in progress.

b. Place transmitting equipment No. 1 in operation by dialing 9, then 8.

c. If a course error is detected during the flight check of transmitting equipment No. 1, perform the course alinement procedure (par. 60).

d. If the flight check determines that adjustments are required in the modulation levels, use the following controls to make these adjustments:

(1) Use SUB-CARRIER LEVEL control R18 on the goniometer (fig. 30) to adjust the subcarrier modulation.

(2) Use R15 on the O–373/FRN (fig. 216) to adjust the identification (keyed tone) modulation.

(3) Use the SIDE BAND LEVEL control on the modulation eliminator (fig. 31) to adjust the variable carrier modulation. Clockwise rotation of the SIDE BAND LEVEL control decreases course width. Counterclockwise rotation of the SIDE BAND LEVEL control increases course width.

e. When the flight check shows that the modulation levels and course alinement are correct, dial 10 to turn off transmitting equipment No. 1.

f. Place transmitting equipment No. 2 in operation by dialing 7, then 6.

g. If the course alinement of transmitting equipment No. 1 was changed (*c* above), perform the course discrepancy adjustment procedure (par. 56).

h. If the flight check of transmitting equipment No. 2 determines that adjustments are required in the modulation levels, refer to *d* above.

i. When the flight check shows that the modulation levels and course alinement are correct, dial 10 to turn off transmitting equipment No. 2.

j. Obtain accurate navigation charts of the area surrounding the site. On the charts, plot the magnetic bearings from the site of frequently used checkpoints and major cities. These checkpoints will help minimize the need for future flight checks.

60. Course Alinement

Note. This adjustment is necessary only when a course error is detected during a flight check (par. 59*c*). On each goniometer, the manufacturer's serial plate is located on the chassis almost directly beneath the drive belt. Check the manufacturer's serial number on the No. 1 goniometer. Goniometers that have a serial number of 614 or above (fig. 30) are adjusted as described below. When making adjustments to goniometers with serial numbers of 613 and below (fig. 30), disregard all references to the locking device for the degree indicator scale and use a screwdriver to adjust control H1.

a. The No. 1 goniometer is located in the No. 1 CY–1899/FRN–22. The mechanical parts on the goniometer that are involved in making the adjustment for course error are shown in figure 30. Raise the latch arm so that it clears the latch plate, and rotate course adjustment control H1 to move the degree indicator scale the required number of degrees in the right direction to remove the course error.

b. Loosen the two screws that hold the latch plate in place. The slot in the latch plate permits the plate to be moved slightly in either direction. Move the latch plate in the proper direction so that the notch in the latch arm engages with the latch plate. Then tighten the latch plate holding screws.

c. On goniometers with locking devices, rotate H1 counterclockwise until a release in the tension on the control can be felt.

d. Perform the phase selector and phase comparator balance adjustments on the monitor as described in paragraphs 52 and 53. Repeat the flight check (par. 59) to make sure that the course was moved in the right direction.

61. Commissioning Omnirange Station

a. Use the operational checklist (par. 229) to make a complete performance check of Radio Transmitting Set AN/FRN–22A from the omnirange site.

Note. Be sure that all circuit breakers on the antenna pedestal (fig. 201), except K1005 for the shelter lights, are in their ON positions before leaving the shelter. Be sure that LOCAL-REMOTE switch on the C–1738/FRN–20 is in the REMOTE position.

b. At the remote control point, connect the power cable from the remote control unit and the AM–1247/FRN–20 to a 115-volt ac power source.

c. Use the operational checklist (par. 229*d*) to make an operational check of the omnirange set from the remote control point, then release the equipment to operating personnel.

CHAPTER 2

THEORY

Section I. GENERAL THEORY OF RADIO TRANSMITTING SET AN/FRN–22A

62. Equipment Applications

(fig. 49, contained in separate envelope)

Radio Transmitting Set AN/FRN–22A is designed to be operated from a remotely located control point. Remote control of transmitting facilities is accomplished over a balanced telephone line and makes possible the following three modes of transmission: omnirange transmission to provide continuous navigational information, coded tone transmission to identify the omnirange station, and voice transmission. The signal paths of the three modes of transmission are described in paragraphs 64 through 66. Circuits for manual and automatic control are described in paragraphs 67 and 68.

63. System Theory

Figure 49 (in separate envelope), shows the block diagram of the omnirange set. The main components, with their common names and functions, are listed below.

a. Antenna AT–669/FRN–22 (Antenna). Radiates a very high frequency (VHF) omnirange signal consisting of a reference carrier and two variable-carrier signals.

b. Antenna Group AN/FRA–14. Samples and detects the RF signal radiated by Antenna AT–669/FRN–22 and feeds it to Course Monitor MX–1837/FRN–20.

c. Audio-Frequency Amplifier AM–1246/FRN–20. Amplifies the 50- or 60-cycle signal from Audio Frequency Oscillator O–371/FRN–20 to a level of 115 volts to operate the motor in Electrical Goniometer GO–12/FRN–20.

d. Audio-Frequency Amplifier AM–1247/FRN–20. Amplifies the audio signal from microphone MK1 to produce a constant output level of 0 db.

e. Audio-Frequency Oscillator O–371/FRN. Generates a frequency regulated 50- or 60-cycle signal and feeds it to Audio-Frequency Amplifier AM–1246/FRN–20.

f. Audio-Frequency Oscillator O–373/FRN. Develops and supplies a 1,000-cycle identification tone signal to Keyer KY–175/FRN. It has a self-contained plate supply.

g. Course Monitor MX–1837/FRN–20 (Monitor). Receives the detected signal from Antenna Group AN/FRA–14 and compares it with preset standards of input level, phase relationship and amplitude. It also provides fail-safe protection and amplifies the signal for aural monitoring.

h. Electrical Goniometer GO–12/FRN–20 (Goniometer). Couples the unmodulated RF signal from Course Monitor MX–1837/FRN–20 to the variable sections of Antenna AT–669/FRN–22. It generates an FM subcarrier that amplitude modulates Radio Transmitter T–573/FRN–22A. It also provides level adjustments and mixes the subcarrier and identification signals or the subcarrier and voice modulating signals before they are applied to the transmitter.

i. Indicator Panel SB–830/FRN–22A (Meter Panel). Indicates the frequency and voltage of the power supplied to the goniometer motor in equipment No. 1 or No. 2. It also indicates the amplifier and cathode currents in Audio-Frequency Amplifier AM–1246/FRN–20 in equipment No. 1.

j. Keyer KY–175/FRN (Keyer). Forms the call letters of the station by mechanically interrupting the 1,000-cycle tone signal produced by Audio-Frequency Oscillator O–373/FRN.

k. Modulation Eliminator MX–1843/FRN–20 (Modulation Eliminator). Removes the modulation from the modulated RF carrier produced by Radio Transmitter T–573/FRN–20. Amplifies the unmodulated carrier and feeds it to Electrical Goniometer GO–12/FRN–20.

l. Power Supply PP–1329/FRN–20. Supplies +500 volts and +1,350 volts to Audio-Frequency Amplifier AM–1246/FRN–20. Houses output

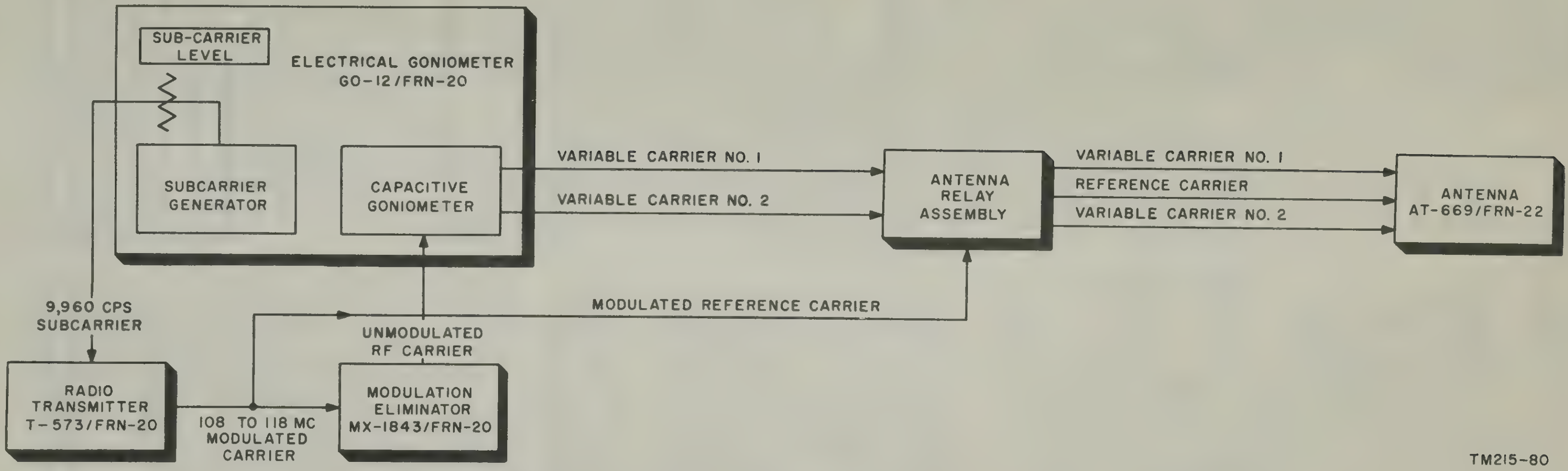


Figure 50. Navigational information signal path, block diagram.

transformer T1403, which couples Audio-Frequency Amplifier AM–1246/FRN–20 to Electrical Goniometer GO–12/FRN–20.

m. Power Supply PP–1331/FRN–20. Supplies +500 volts and +250 volts to Radio Transmitter T–573/FRN–22A, and +250 volts to the subcarrier section of Electrical Goniometer GO–12/FRN–20. It also supplies —25 volts and —75 volts bias to Radio Transmitter T–573/FRN–22A, and +12 volts to Relay Assembly RE–248/FRN–22.

n. Power Supply PP–1415/FRN–22. Supplies 12 volts for operating the telephone circuits between the site and remote control points.

o. Propeller Ventilating Fan HD–244/FRN–22 (Shelter Blower). Provides thermostatically controlled forced air cooling for the shelter.

p. Radio Set Control C–1738/FRN–20. Provides functions for turning the transmitter on and off and signaling the operator at the remote point.

q. Radio Set Control C–1739/FRN–20 (Remote Control Unit). Provides control of the omnirange set from the remote position. Provides intercommunication between the site and the remote control point, and voice modulation of the transmitter.

r. Radio Set Transfer Control C–1840/FRN–22. Automatically dials the standby transmitting equipment to omnirange operation when actuated by an alarm from Course Monitor MX–1837/FRN–20.

s. Radio Transmitter T–573/FRN–22A (Transmitter). Develops and amplifies an RF signal between 108 and 118 mc with an output power of 50 watts.

t. Relay Assembly RE–247/FRN–22. Provides facilities for controlling the ac power to various components of the omnirange set.

u. Relay Assembly RE–248/FRN–22. Houses control circuits that perform functions such as transferring identification, voice, and 12-volt circuits between equipments No. 1 and No. 2.

v. Voltage Regulator CN–358/FRN–22 (Voltage Regulator). Supplies a stable source of 230 volts ac power for operation of components in the omnirange set.

64. Navigational Information Signal Path

(fig. 50)

a. A 9,960-cycle reference subcarrier is generated in the goniometer where it is frequency-modulated at a 30-cycle rate by a rotating capacitor. The reference subcarrier is applied to the modulator section of the transmitter where it amplitude-modulates the VHF carrier. The modulated carrier passes through a coaxial relay to the reference section of the antenna and is radiated omnidirectionally.

b. A portion of the transmitter output is fed to the modulation eliminator where it is amplified and the modulation removed. The output from the modulation eliminator passes through the goniometer VHF capacitor which divides the signal into two exactly equal 30-cycle modulated parts displaced 90° in phase. The output of the goniometer capacitor is connected through two coaxial relays to the two variable sections of the antenna and radiated in the form of a rotating figure-of-eight pattern. The combined radiation (total of reference and variable carrier radiations) produces a rotating pattern which carries distinctive bearing information along any radial from the omnirange set.

65. Station Identification Signal Path

(fig. 51)

A 1,000-cycle tone is generated in O–373/FRN and passed through the keyer which produces the station call letters at predetermined intervals of 16 to 100 seconds. The keyed tone goes through the equipment services selector relay in the RE–248/FRN–22, through the tone-voice selector relay in the C–1738/FRN–20, through an attenuator in the goniometer, and then to the modulator section in the transmitter. The keyed-tone signal amplitude-modulates the 108- to 118-megacycle carrier which is developed in the transmitter and radiated by the reference section of the antenna.

66. Voice Signal Path

(fig. 52)

Voice signals that are developed in the operator's microphone are fed through the remote control unit to the AM–1247/FRN–20, where they are amplified and compressed to a preset level. The output of the AM–1247/FRN–20 is carried through the remote control unit and over the balanced telephone line to the tone-voice selector relay in the C–1738/FRN–20. The signals from this point are routed through an attenuator in the goniometer to the modulator section of the transmitter. The voice signals amplitude-modulate the 108- to 118-mc carrier.

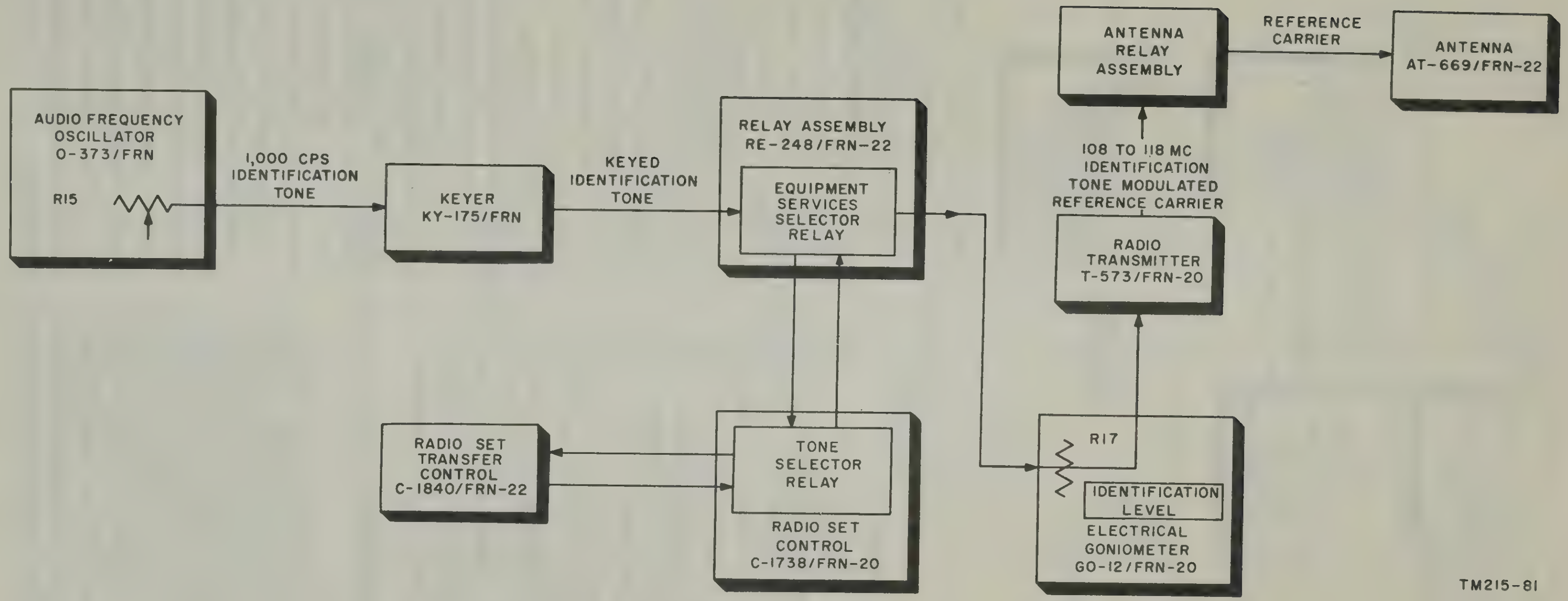


Figure 51. Station identification signal path, block diagram.

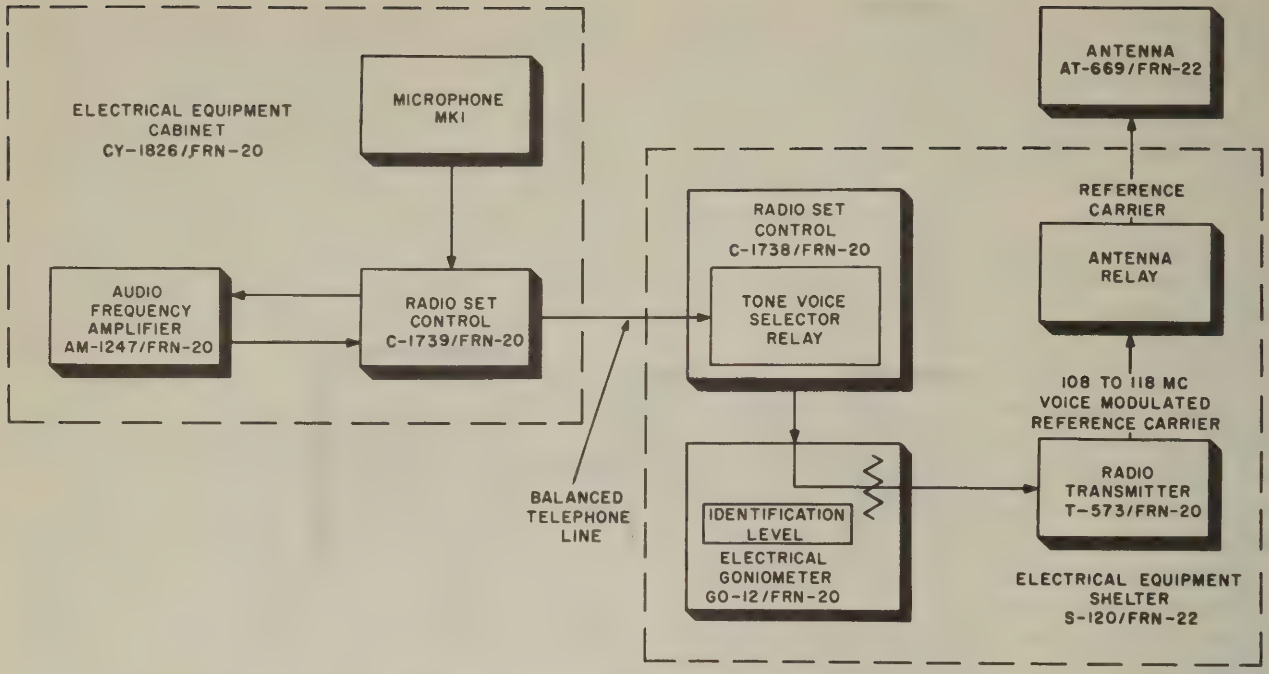

ELECTRICAL EQUIPMENT CABINET CY-1826/FRN-20
MICROPHONE MKI
AUDIO FREQUENCY AMPLIFIER AM-1247/FRN-20
RADIO SET CONTROL C-1739/FRN-20
BALANCED TELEPHONE LINE
RADIO SET CONTROL C-1738/FRN-20
TONE VOICE SELECTOR RELAY
IDENTIFICATION LEVEL
ELECTRICAL GONIOMETER GO-12/FRN-20
ANTENNA AT-669/FRN-22
REFERENCE CARRIER
ANTENNA RELAY
108 TO 118 MC VOICE MODULATED REFERENCE CARRIER
RADIO TRANSMITTER T-573/FRN-20
ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
TM215-82

Figure 52. Voice signal path, block diagram.

67. Manual Control Circuit

(fig. 53)

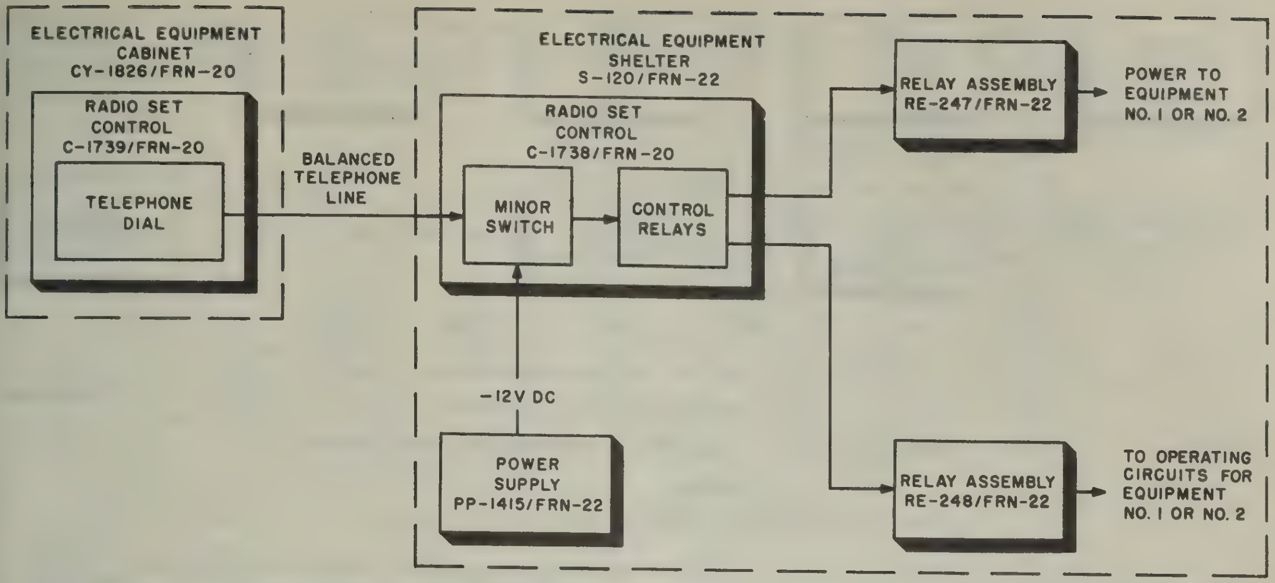
Dialing at the remote control unit transmits 60-cycle current pulses over the balanced telephone line; the current is rectified, and energizes a minor switch in the C–1738/FRN–20. Following completion of the dialing sequence, a —12-volt potential from the PP–1415/FRN–22 is applied through the closed contacts of the minor switch and actuates control relays in the RE–248/FRN–22, in the C–1738/FRN–20, and in the RE–247/FRN–22. The control relays apply the required operating power and complete the operating circuits to either transmitting equipment No. 1 or transmitting equipment No. 2, depending upon the numbers dialed by the operator.

68. Automatic Control Circuit

(fig. 54)

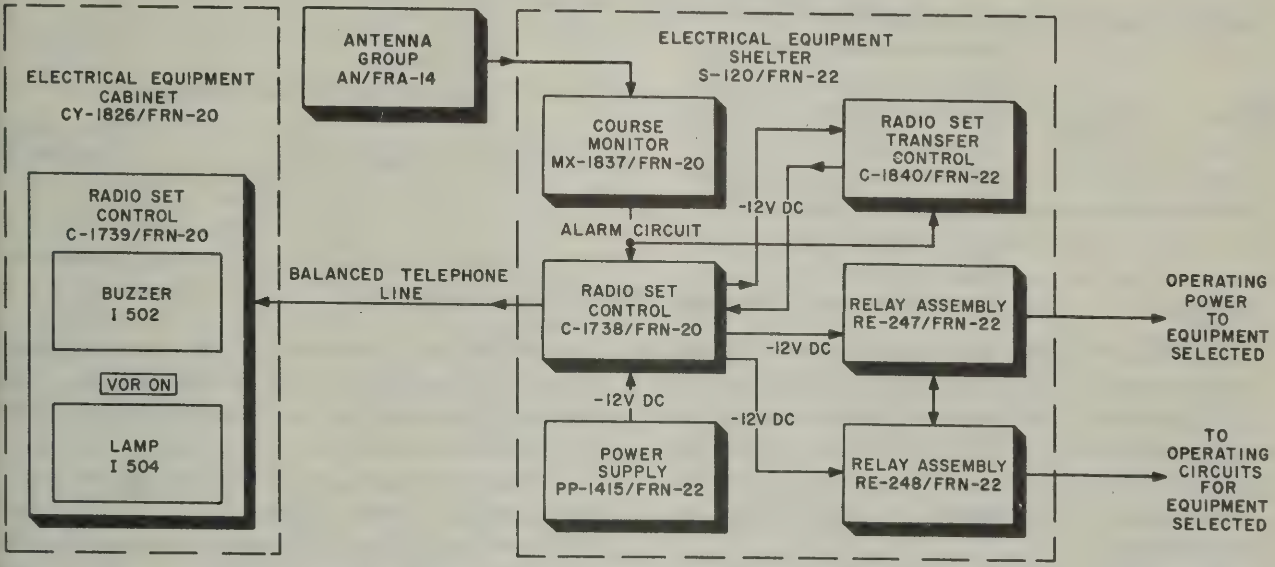
a. Signals produced by the omnirange set are monitored continuously by the monitor through the AN/FRA–14. Interruption, or change in characteristics, of signals emitted by the transmitting equipment causes the circuits in the monitor to cycle, in an effort to put the transmitter back on the air. This causes a relay in the C–1738/FRN–20 to turn off the transmitting equipment responsible for abnormal emission. The abnormal condition also causes a relay in the C–1840/FRN–22 to disable the manual control circuit and start a motor-driven sequence switch. Through the action of the sequence switch, a —12-volt potential from the PP–1415/FRN–22 actuates control relays in the RE–248/FRN–22, in the C–1738/FRN–20, and in the RE–247/FRN–22. When the switching sequence is completed, the standby transmitting equipment is automatically placed in operation and the monitor samples emission characteristics.

b. If the emission characteristics are found normal, the monitor will remain alarm-free until some future condition of abnormality develops in the transmitting equipment. If emission is found abnormal after a transfer, the monitor will place the original transmitting equipment in operation as described in *a* above. This process of sampling and transfer will continue for a maximum of six transfer cycles. If, at the end of the sixth cycle, the monitor has found that neither transmitting equipment is capable of producing normal emission, the transfer unit will go through a seventh cycle. The seventh cycle automatically removes operating power from both transmitting equipments and stops further cycling of the transfer unit. Indicating lamps and a buzzer, located on the remote control unit provide a warning to the operator that the omnirange set is disabled and that maintenance procedures are necessary.


ELECTRICAL EQUIPMENT CABINET CY-1826/FRN-20
RADIO SET CONTROL C-1739/FRN-20
TELEPHONE DIAL
BALANCED TELEPHONE LINE
ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
RADIO SET CONTROL C-1738/FRN-20
MINOR SWITCH
CONTROL RELAYS
-12V DC
POWER SUPPLY PP-1415/FRN-22
RELAY ASSEMBLY RE-247/FRN-22
POWER TO EQUIPMENT NO. 1 OR NO. 2
RELAY ASSEMBLY RE-248/FRN-22
TO OPERATING CIRCUITS FOR EQUIPMENT NO. 1 OR NO. 2

TM215-83

Figure 53. Manual control circuit, block diagram.


ELECTRICAL EQUIPMENT CABINET CY-1826/FRN-20
RADIO SET CONTROL C-1739/FRN-20
BUZZER I 502
VOR ON
LAMP I 504
ANTENNA GROUP AN/FRA-14
BALANCED TELEPHONE LINE
ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
COURSE MONITOR MX-1837/FRN-20
ALARM CIRCUIT
RADIO SET TRANSFER CONTROL C-1840/FRN-22
-12V DC
RADIO SET CONTROL C-1738/FRN-20
-12V DC
-12V DC
-12V DC
POWER SUPPLY PP-1415/FRN-22
RELAY ASSEMBLY RE-247/FRN-22
RELAY ASSEMBLY RE-248/FRN-22
OPERATING POWER TO EQUIPMENT SELECTED
TO OPERATING CIRCUITS FOR EQUIPMENT SELECTED

TM215-84

Figure 54. Automatic control circuit, block diagram.

Section II. THEORY OF RADIO TRANSMITTER T-573/FRN-20

69. Block Diagram

(fig. 55)

The transmitter is capable of developing a carrier output of 50 watts on modulated continuous wave or voice-modulated operation within the frequency range of 108 to 118 mc. For complete circuit details, refer to the overall schematic diagram (fig. 275).

a. The 27- to 29.5-mc signal (crystal frequency) developed in crystal oscillator V1 is amplified and doubled in frequency successively by doubler amplifiers V2 and V3. The output signal of V3 is at the carrier frequency and is coupled to final amplifier V4. High level modulation is accomplished by the output of push-pull modulator V7 and V8. The output of final amplifier V4 is connected to the modulation eliminator and to the antenna.

b. The two audio signals used to modulate the transmitter carrier are applied to push-pull driver

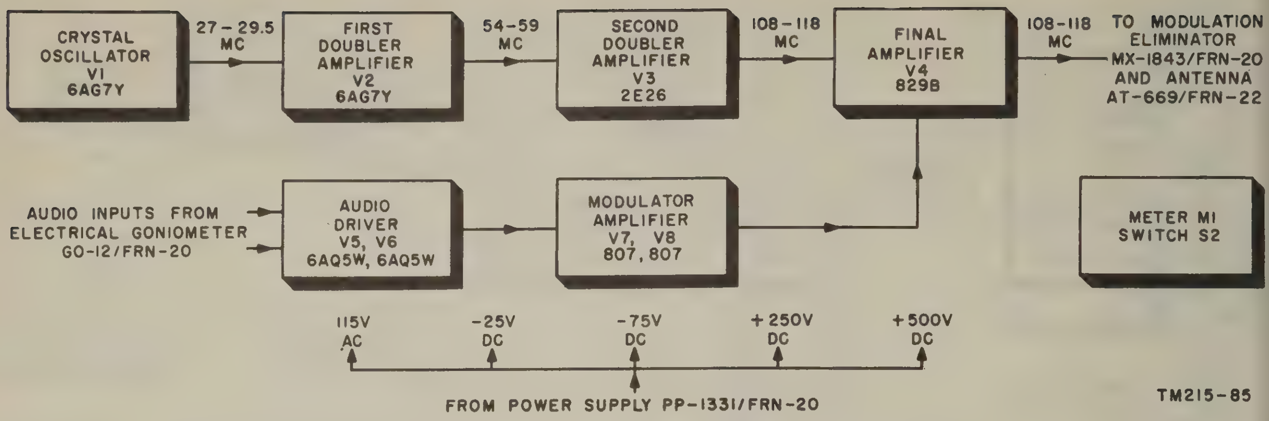

CRYSTAL OSCILLATOR V1 6AG7Y
27-29.5 MC
FIRST DOUBLER AMPLIFIER V2 6AG7Y
54-59 MC
SECOND DOUBLER AMPLIFIER V3 2E26
108-118 MC
FINAL AMPLIFIER V4 829B
108-118 MC
TO MODULATION ELIMINATOR MX-1843/FRN-20 AND ANTENNA AT-669/FRN-22
AUDIO INPUTS FROM ELECTRICAL GONIOMETER GO-12/FRN-20
AUDIO DRIVER V5, V6 6AQ5W, 6AQ5W
MODULATOR AMPLIFIER V7, V8 807, 807
METER M1 SWITCH S2
115V AC
-25V DC
-75V DC
+250V DC
+500V DC
FROM POWER SUPPLY PP-1331/FRN-20
TM215-85

Figure 55. Radio Transmitter T-573/FRN-20, block diagram.

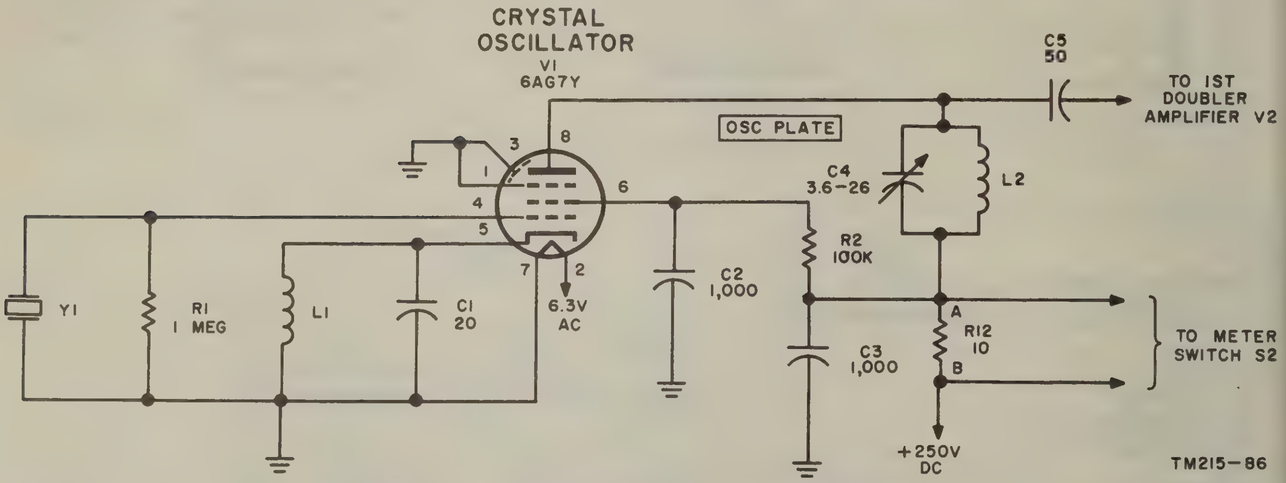


Figure 56. Crystal oscillator V1, schematic diagram.

V5 and V6. The output of audio driver V5 and V6 is coupled to push-pull modulator V7 and V8.

c. Dc operating voltages for the transmitter are developed in the PP-1331/FRN-20. The voltages supplied to the transmitter are —25 volts dc, —75 volts dc, +250 volts dc, +500 volts dc, and 115 volts ac.

d. A meter and meter-switching circuits are provided to check voltages and currents in the transmitter.

70. Crystal Oscillator V1

(fig. 56)

An electron-coupled crystal oscillator circuit develops the initial signal in the transmitter and feeds it to first doubler amplifier V2. The frequency of the crystal oscillator may be any frequency between 27 and 29.5 mc. Pentode V1, a 6AG7Y, is used as the oscillator.

a. Quartz crystal Y1, a harmonic mode crystal, is connected between the control grid of V1 and ground. Excitation of crystal Y1 is caused by the oscillations produced by the parallel-tuned circuit (L1 and C1) in the cathode of V1. The resonant frequency of this tuned circuit is below the oscillator frequency.

b. The screen grid of V1 serves as the oscillator anode. Screen voltage for V1 is furnished by the 250-volt supply through resistor R2. Resistor R2 and capacitor C2 form a decoupling filter which bypasses RF signals from screen to ground.

c. Dc bias voltage for the control grid of V1 is provided by the voltage drop across grid resistor R1. The suppressor grid of V1 is grounded to provide shielding between the oscillator circuit and the plate circuit. The RF signal from the oscillator circuit is coupled to the plate through the common electron stream.

d. The output is developed across a parallel-tuned circuit consisting of inductor L2 and OSC PLATE tuning capacitor C4. This circuit is tuned to a frequency one-fourth of the transmitter carrier frequency. Capacitor C3 bypasses

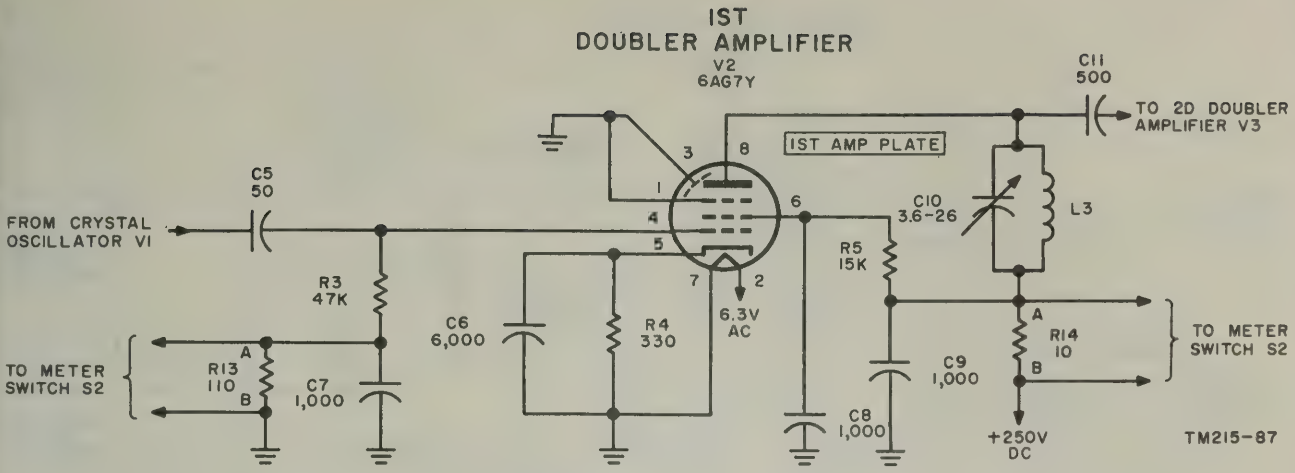


Figure 57. First doubler amplifier V2, schematic diagram.

RF from the plate return to ground. Plate voltage is obtained from the 250-volt supply. Resistor R12 serves as a shunt for meter M1 when meter switch S2 is in the OSC PLATE position.

71. First Doubler Amplifier V2

(fig. 57)

First doubler amplifier V2 uses a 6AG7Y tube to amplify and double the frequency of the signal from crystal oscillator V1.

a. The input signal is coupled to the grid of V2 by capacitor C5. The output of V2 is developed in a parallel-tuned circuit consisting of inductor L3 and 1ST AMP PLATE tuning capacitor C10. The frequency of the signal in this tuned circuit is one-half of the transmitter carrier frequency.

b. Capacitor C9 bypasses RF from plate return to ground. Plate voltage is obtained from the 250-volt supply through resistor R14. Resistor R14 also serves as a meter shunt when meter switch S2 is in the 1ST AMP PLATE position. Screen voltage is supplied through resistor R14 and voltage-dropping resistor R5. The screen grid is bypassed to ground by capacitor C8.

c. Self-bias is developed across cathode resistor R4. The cathode RF bypass capacitor is C6. The grid load resistor is R3. Capacitor C7 is the RF grid bypass. Resistor R13 serves as a shunt for meter M1 when meter switch S2 is in the 1ST AMP GRID position.

72. Second Doubler Amplifier V3

(fig. 58)

Second doubler amplifier V3 uses a 2E26 tube to amplify and double the frequency of the signal from first doubler amplifier V2.

a. The input signal from first doubler amplifier V2 is coupled to the grid of tube V3 by capacitor C11. The output of V3 is developed in a parallel-tuned circuit consisting of inductor L4 and 2ND AMP PLATE tuning capacitor C14. This circuit is tuned to the transmitter carrier frequency. The output of the tuned circuit is transformer-coupled to the grids of final amplifier V4 by inductor L5.

b. Capacitor C15 bypasses RF from plate return to ground. Plate voltage is obtained from the 250-volt supply through resistor R16. Resistor R16 serves as a shunt for meter M1 when meter switch S2 is in the 2ND AMP PLATE position. Screen-grid voltage is obtained from the 250-volt supply through a voltage divider consisting of resistor R7 and EXCITATION CONTROL R8. The screen grid is bypassed to ground by capacitor C13.

c. Grid bias is supplied by the fixed 25-volt bias supply and the voltage drop developed by grid current in resistor R6. Capacitor C12 is the grid RF bypass. Resistor R15 serves as a shunt for meter M1 when meter switch S2 is in the 2ND AMP GRID position.

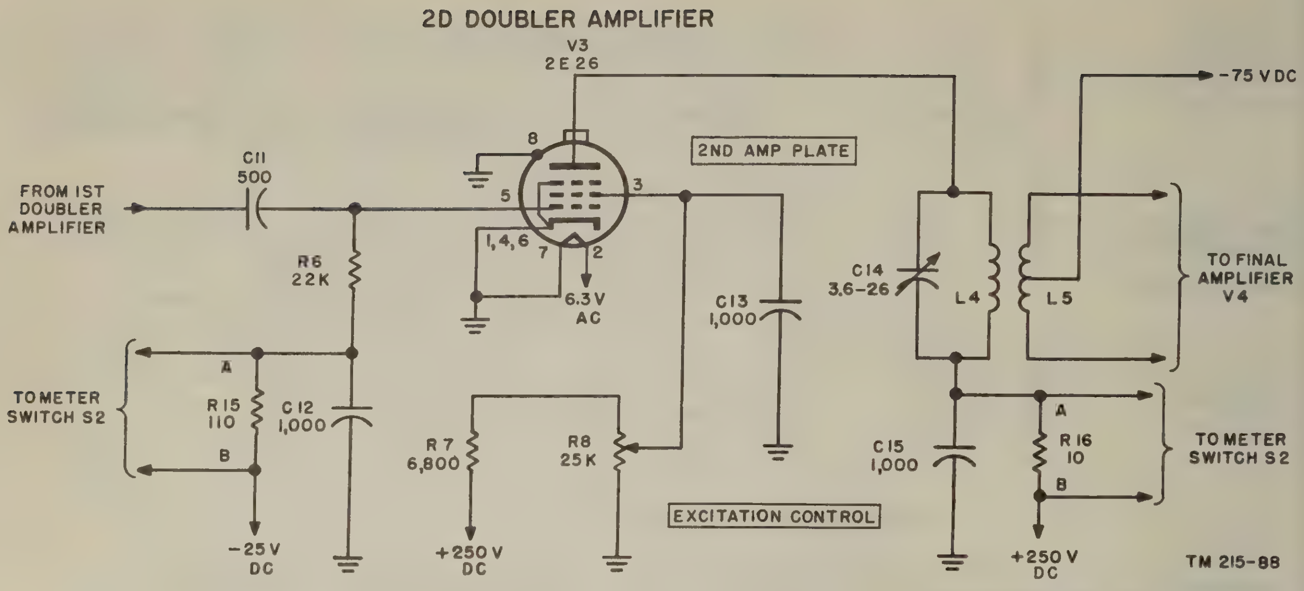


Figure 58. Second doubler amplifier V3, schematic diagram.

73. Final Amplifier V4

(fig. 59)

Final amplifier V4 uses a 829B tube to amplify the signal delivered to it by tube V3. The final amplifier operates as a class C push-pull amplifier, feeding RF power to coaxial output plug P1. Both the plates and screens of V4 are modulated.

a. Excitation is supplied to the push-pull grids of V4 from a parallel-tuned circuit consisting of inductor L5 and FINAL AMP GRID tuning capacitor C16–C17. Capacitor C16–C17 is a dual capacitor with a grounded rotor. A fixed grid bias is obtained from the —75-volt bias supply through resistor R17 which is connected to the center tap of inductor L5. Resistor R17 serves as a shunt for meter M1 when meter switch S2 is in the FINAL AMP GRID position. Neutralization is provided by a small insulated metal flag connected to each grid and located outside the tube near the opposite plate.

b. The output of V4 is developed in a parallel-tuned circuit consisting of inductor L7 and FINAL AMP PLATE tuning capacitor C20–C21. Capacitor C20–C21 is a dual capacitor with an ungrounded rotor. Plate voltage from modulation transformer T3 is fed to the center tap of L7 through RF choke L6.

c. Modulating voltage is supplied to the screen grids through a fixed voltage divider consisting of resistors R10 and R11. RF currents in the screens are bypassed to ground by capacitors C19 and C31. Resistor R18 serves as a shunt for meter M1 when meter switch S2 is in the FINAL AMP SCRN position.

d. Modulated RF power is coupled from the plate circuit to 52-ohm coaxial output plug P1 by loop L8 which is series-tuned by ANTENNA LOADING capacitor C24.

e. A sample of the modulated RF power is coupled to coaxial CARRIER TEST OUT receptacle J3 by a short length of 52-ohm coaxial cable. The dielectric and inner conductor of the cable section extend beyond the outer conductor to form an adjustable probe near inductor L7.

f. Metering of the sum of all currents in V4 is accomplished across cathode resistor R9 when meter switch S2 is in the FINAL AMP TOTAL position. The cathode is bypassed by capacitors C18 and C28. The filament is bypassed to ground by capacitors C29 and C30.

74. Audio Driver V5 and V6

(fig. 60)

Audio driver V5 and V6, type 6AQ5W pentodes, operates as a class A push-pull amplifier to provide grid drive for modulator V7 and V8.

a. An audio signal, consisting of either subcarrier and keyed tone, or subcarrier and voice, is applied to the primary of line-to-grid transformer T1 through MODULATION GAIN control AT1. The secondary of T1 feeds the grids of

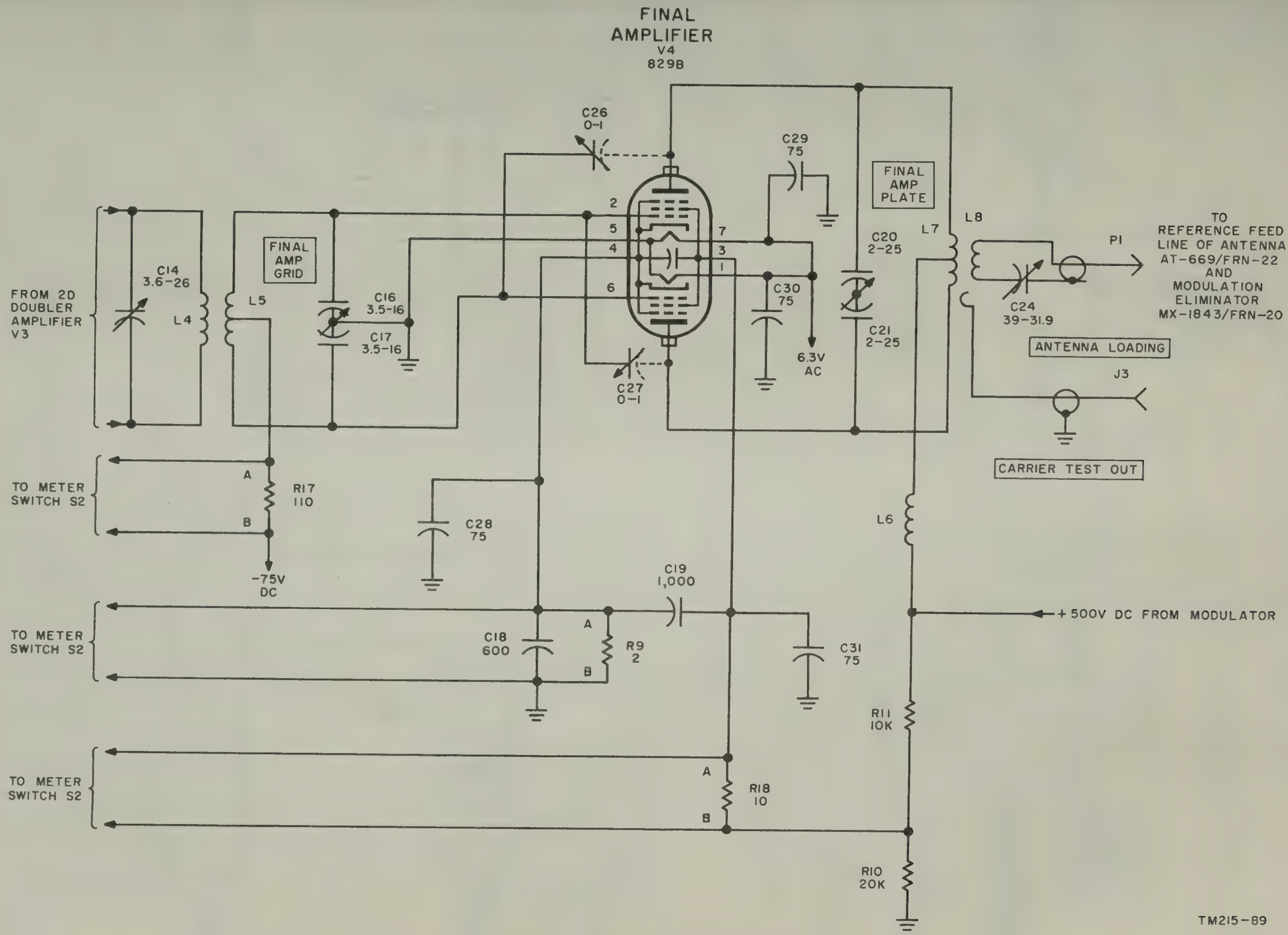


Figure 59. Final amplifier V4, schematic diagram.

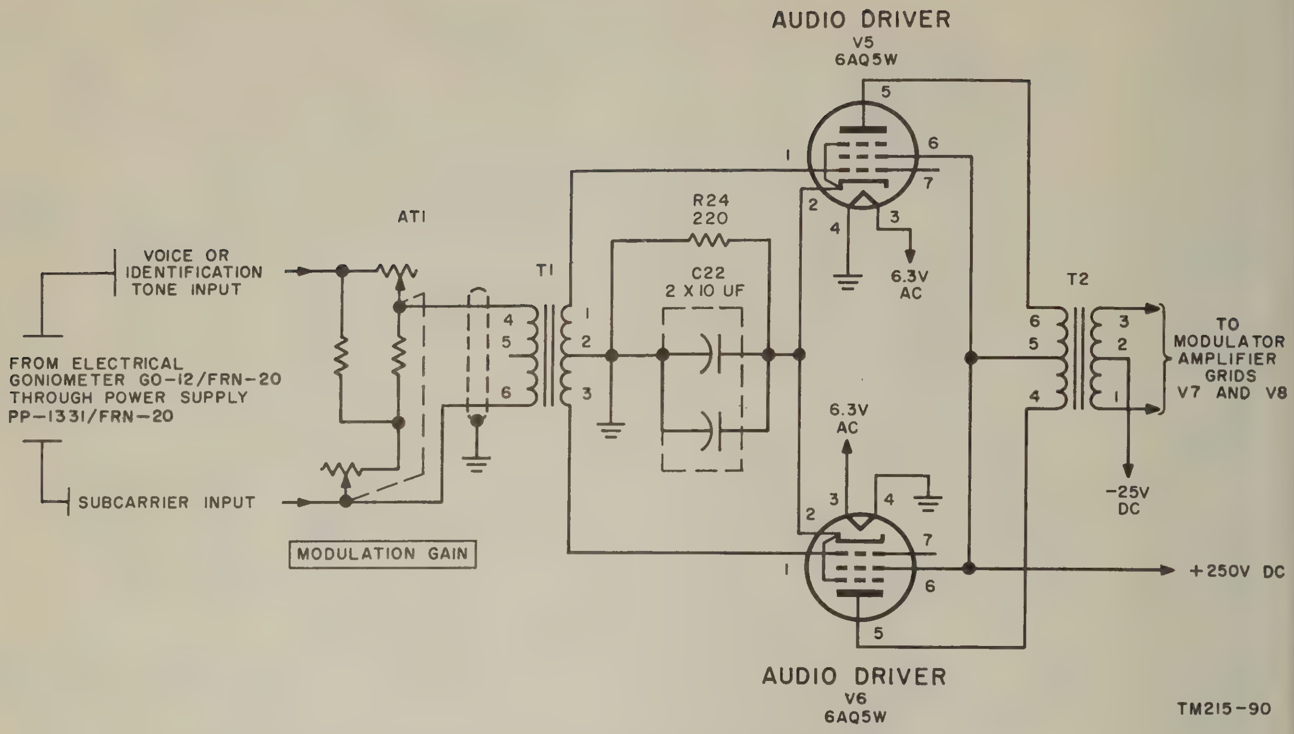

AUDIO DRIVER
V5
6AQ5W
AT1
VOICE OR IDENTIFICATION TONE INPUT
FROM ELECTRICAL GONIOMETER GO-12/FRN-20 THROUGH POWER SUPPLY PP-1331/FRN-20
SUBCARRIER INPUT
MODULATION GAIN
T1
R24
220
C22
2 X 10 UF
6.3V AC
6.3V AC
T2
TO MODULATOR AMPLIFIER GRIDS V7 AND V8
-25V DC
+250V DC
AUDIO DRIVER
V6
6AQ5W
TM215-90

Figure 60. Audio driver V5 and V6, schematic diagram.

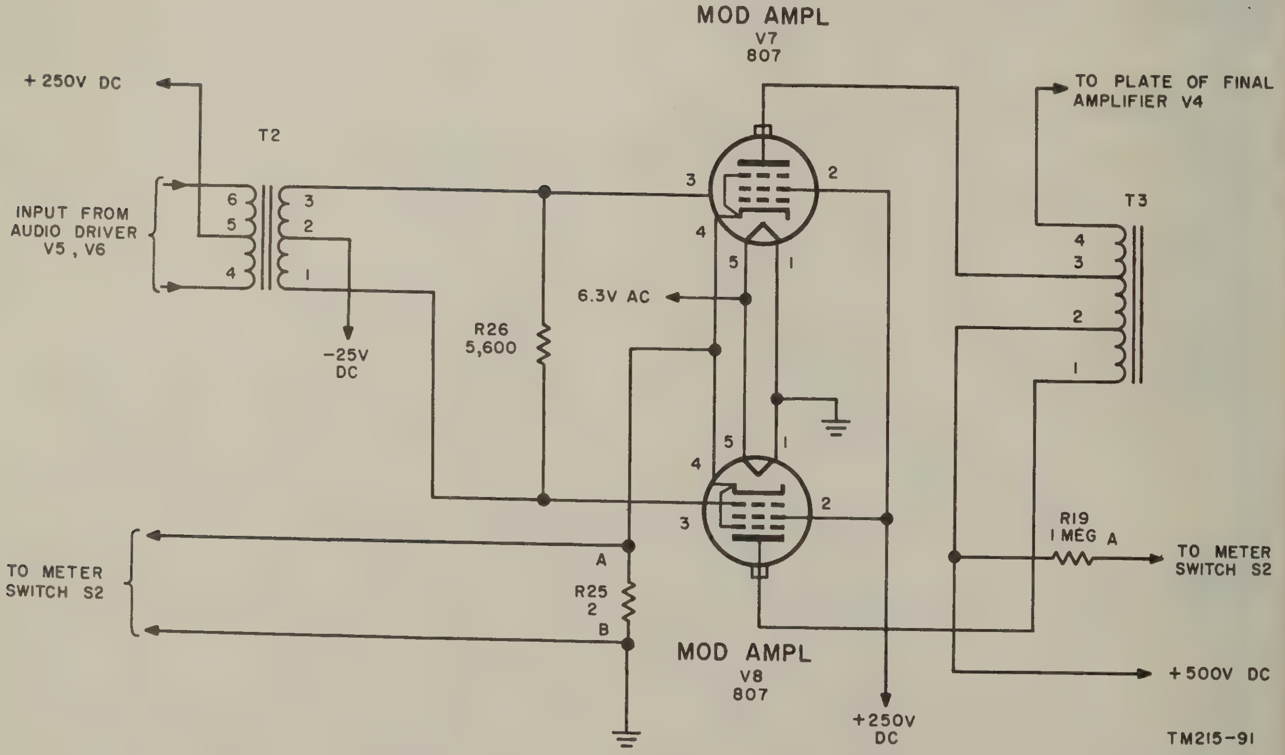


Figure 61. Modulator V7 and V8, schematic diagram.

V5 and V6 in push-pull. Bias is provided by cathode resistor R24, bypassed by C22.

b. Plate and screen-grid voltage for V5 and V6 is provided by the 250-volt supply. Output power is developed in driver transformer T2.

75. Modulator V7 and V8

(fig. 61)

Push-pull modulator V7 and V8, 807 pentodes, operates as a class B amplifier. The power output of this stage, developed in modulation transformer T3, is used to modulate final RF amplifier V4.

a. The signal input from driver transformer T2 is applied to the grids of tubes V7 and V8. Fixed grid bias is supplied directly from the —25-volt bias supply to the center tap of the T2 secondary. Regulating resistor R26 provides a constant shunt load across the secondary of T2.

b. Audio output power is developed in modulation autotransformer T3. Transformer T3 matches the plate impedance of tubes V7 and V8 to the higher impedance of final amplifier V4. The plate voltage for V7 and V8, and the plate and screen grid voltage for V4, is provided by direct connection of the 500-volt supply to the tap of T3. The screens of V7 and V8 are supplied by the 250-volt supply.

c. Resistor R19 serves as a voltmeter multiplier and connects the 500-volt supply to meter M1 when meter switch S2 is in the HIGH VOLTAGE position. Total current in V7 and V8 is metered across cathode resistor R25 when meter switch S2 is in the MOD TOTAL position.

76. Power Circuits

(fig. 62)

Operating voltages for the transmitter are supplied by the PP–1331/FRN–20 through receptacles J1 and J2.

a. Transformer T4 steps down the 115-volt ac power to 6.3 volts ac for all tube filaments in the transmitter.

b. All dc voltages required are developed in the PP–1331/FRN–20. The +500 volts dc is applied through high-voltage receptacle J2 to the screen of V4 and to the plates of V4, V7, and V8. The +250 volts dc is applied through J1 to the plates and screens of V1, V2, V3, V5, and V6 and to the screens of V7 and V8. The —75 volts dc is applied to the grids of V4, and the —25 volts dc is applied to the grids of V3, V7, and V8.

c. Panel interlock switch S3 is for the protection of maintenance personnel. TEST KEY S4, when depressed, causes the 250-volt and 500-volt supplies to be energized. TEST KEY S4 is used only during tuning or test procedures.

77. Meter Circuits

(fig. 63)

Metering of the circuits is accomplished with meter M1, 10-position meter switch S2, and a current shunt resistor or a voltage multiplier resistor in the circuit to be metered. Full-scale range of meter M1 is 1 milliampere, with an internal resistance of 1,000 ohms. Capacitor C25 is bridged across the meter terminals to bypass any RF currents. Each metering resistor is connected to a pair of contacts on meter switch S2.

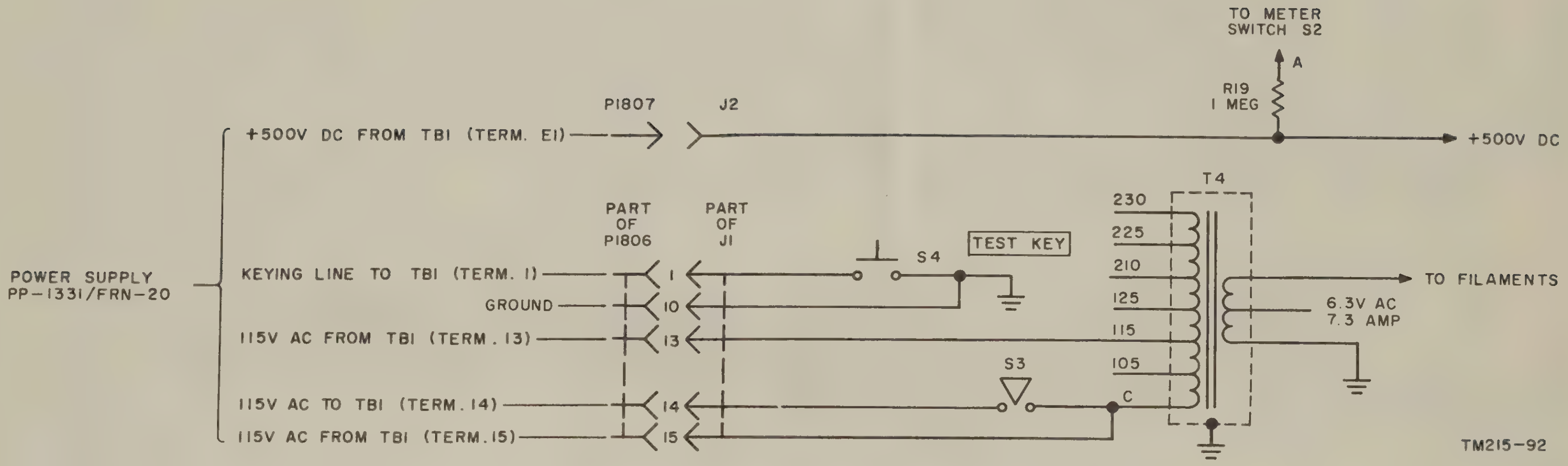


Figure 62. Power circuits, schematic diagram.

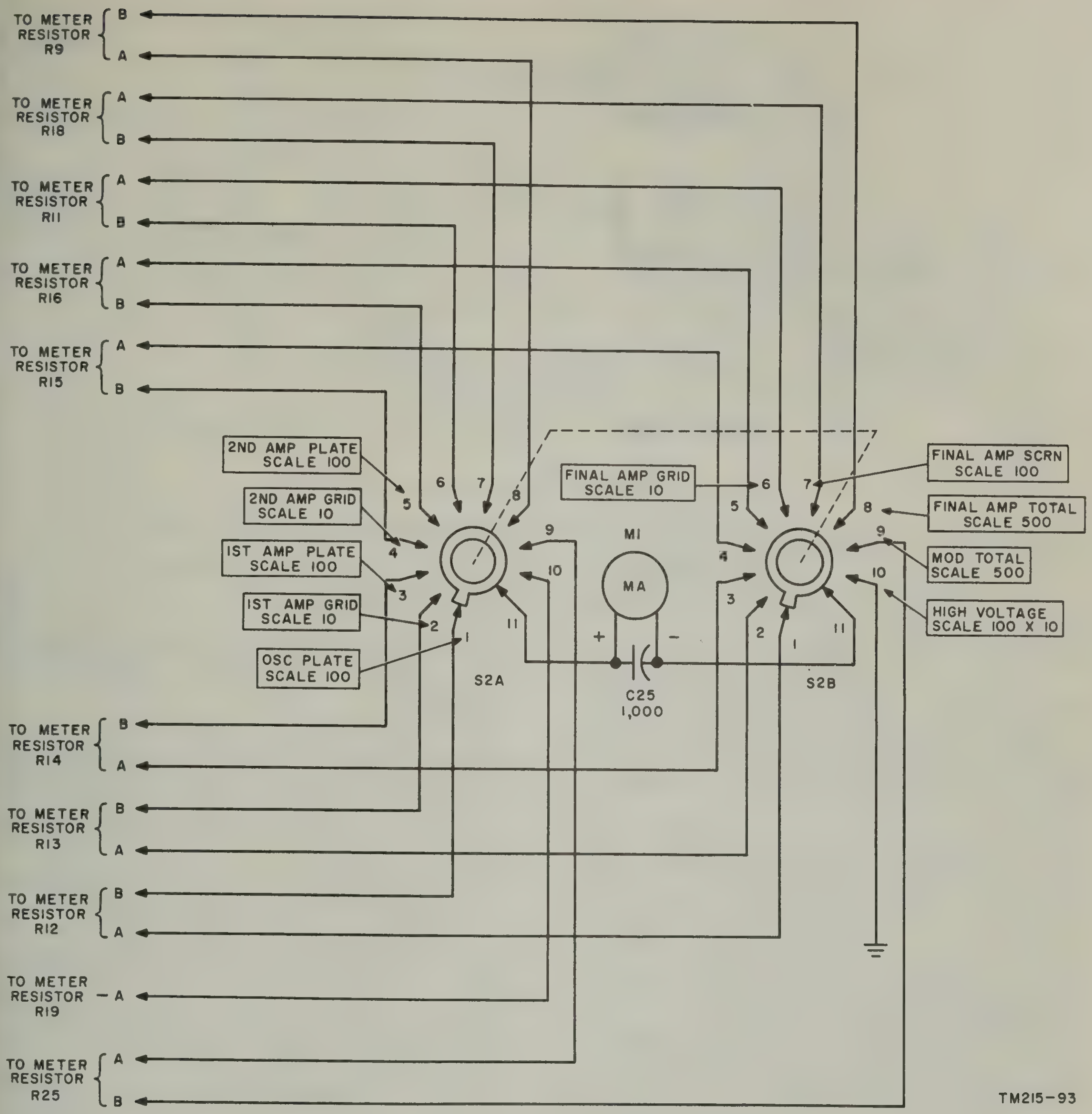

TO METER RESISTOR R9 B A
TO METER RESISTOR R18 A B
TO METER RESISTOR R11 A B
TO METER RESISTOR R16 A B
TO METER RESISTOR R15 A B
2ND AMP PLATE SCALE 100
2ND AMP GRID SCALE 10
1ST AMP PLATE SCALE 100
1ST AMP GRID SCALE 10
OSC PLATE SCALE 100
FINAL AMP GRID SCALE 10
FINAL AMP SCRN SCALE 100
FINAL AMP TOTAL SCALE 500
MOD TOTAL SCALE 500
HIGH VOLTAGE SCALE 100 X 10
M1
MA
+
−
C25 1,000
S2A
S2B
1
2
3
4
5
6
7
8
9
10
11
TO METER RESISTOR R14 B A
TO METER RESISTOR R13 B A
TO METER RESISTOR R12 B A
TO METER RESISTOR R19 — A
TO METER RESISTOR R25 A B
TM215-93

Figure 63. Meter circuits, schematic diagram.

Section III. THEORY OF POWER SUPPLY PP-1331/FRN-20

78. Block Diagram

(fig. 64)

The PP-1331/FRN-20 supplies the operating voltages for the transmitter, the subcarrier section of the goniometer, and the simplex circuit. The power supply consists of four rectifier circuits and their associated controls. For complete circuit details, refer to the overall schematic diagram (fig. 276).

a. Full-wave high-voltage rectifier V1 and V2 provides +500 volts dc for the transmitter.

b. Full-wave low-voltage rectifier V3 provides +250 volts dc for the transmitter and the subcarrier section of the goniometer.

c. Full-wave bias rectifier V4 supplies —25 volts dc and —75 volts dc for the transmitter.

d. Full-wave 12-volt rectifier D1 supplies +12 volts dc for the simplex circuit.

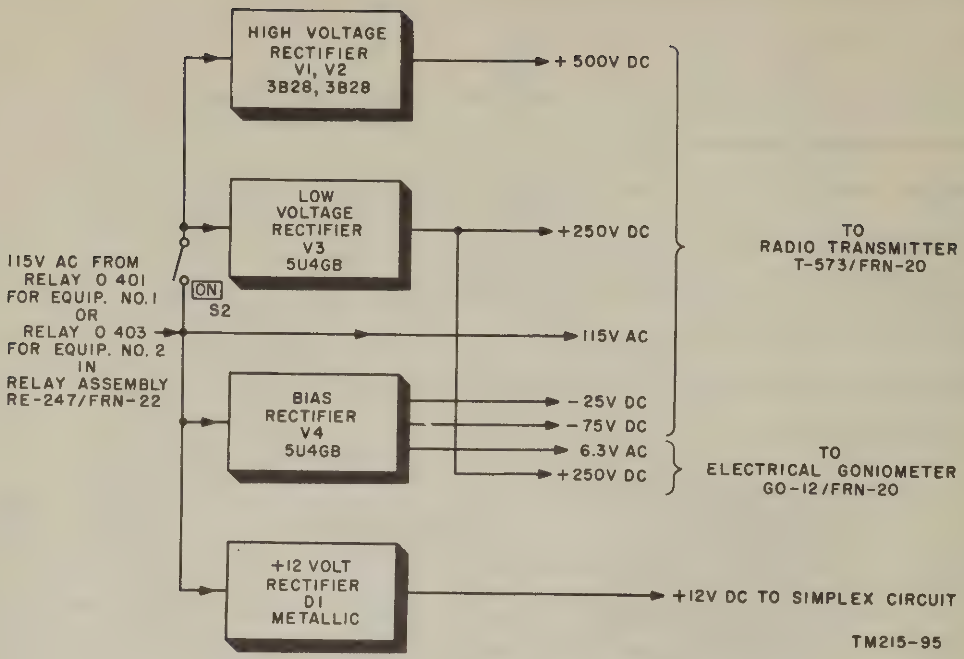

HIGH VOLTAGE RECTIFIER V1, V2 3B28, 3B28
+500V DC
LOW VOLTAGE RECTIFIER V3 5U4GB
+250V DC
TO RADIO TRANSMITTER T-573/FRN-20
115V AC FROM RELAY O 401 FOR EQUIP. NO. 1 OR RELAY O 403 FOR EQUIP. NO. 2 IN RELAY ASSEMBLY RE-247/FRN-22
ON
S2
115V AC
BIAS RECTIFIER V4 5U4GB
-25V DC
-75V DC
6.3V AC
+250V DC
TO ELECTRICAL GONIOMETER GO-12/FRN-20
+12 VOLT RECTIFIER D1 METALLIC
+12V DC TO SIMPLEX CIRCUIT
TM215-95

Figure 64. Power Supply PP-1331/FRN-20, block diagram.

79. High-Voltage Rectifier V1 and V2

(fig. 65, contained in separate envelope)

This circuit supplies +500 volts dc for the modulator and final amplifier of the transmitter. Tubes V1 and V2, 3B28 gas-filled rectifiers, are used.

a. A voltage of 115 volts ac is applied through thermal time-delay relay S3 and contacts of bias underload relay S4 (fig. 276) to the primary of transformer T1. A center-tapped secondary winding of T1 furnishes 645 volts ac to the plates of V1 and V2. Fuse F5, between the center tap and ground is an overload protection.

b. Each of the filaments of the two 3B28 rectifiers is connected across one-half of the 5-volt winding on transformer T2.

c. The output of the high-voltage rectifier is connected through a two-section choke input filter, consisting of chokes L1 and L2 and capacitors C1 and C2, to provide +500 volts dc at terminal E1. Bleeder resistor R1 provides the necessary bleeder current for regulation, and for safety, provides a discharge path for capacitors C1 and C2 after the power supply is turned off.

80. Low-Voltage Rectifier V3

(fig. 65, contained in separate envelope)

A low-voltage rectifier circuit is used to develop +250 volts dc for plates and screen grids of tubes in the transmitter and for the subcarrier section of the goniometer. Tube V3, a 5U4GB, is the rectifier.

a. A voltage of 115 volts ac is applied to the primary of plate transformer T3 through thermal time-delay relay S3 and contacts of bias underload relay S4. A center-tapped secondary winding of T3 furnishes 550 volts ac to the plates of full-wave rectifier V3. Fuse F3, between the center tap and ground, is an overload protection.

b. The filament of the 5U4GB rectifier receives its power from a 5-volt winding on transformer T2.

c. The output is connected through a capacitive input filter, consisting of capacitors C3, C4, and choke L3, and the contacts of bias underload relay S4. The output provides +250 volts dc at terminals 7 and 8 of terminal board TB1. Bleeder resistor R2 provides the necessary bleeder current for regulation, and for safety, a discharge path for capacitors C3 and C4 after the power supply is turned off.

81. Twelve-Volt Rectifier D1

(fig. 65, contained in separate envelope)

A 12-volt rectifier circuit is used to develop +12 volts direct current (dc) for operation of carrier control relay S5, tone-voice relay O208 in the C–1738/FRN–20, and the simplex circuit. Dry-disk metallic bridge-rectifier D1 is used.

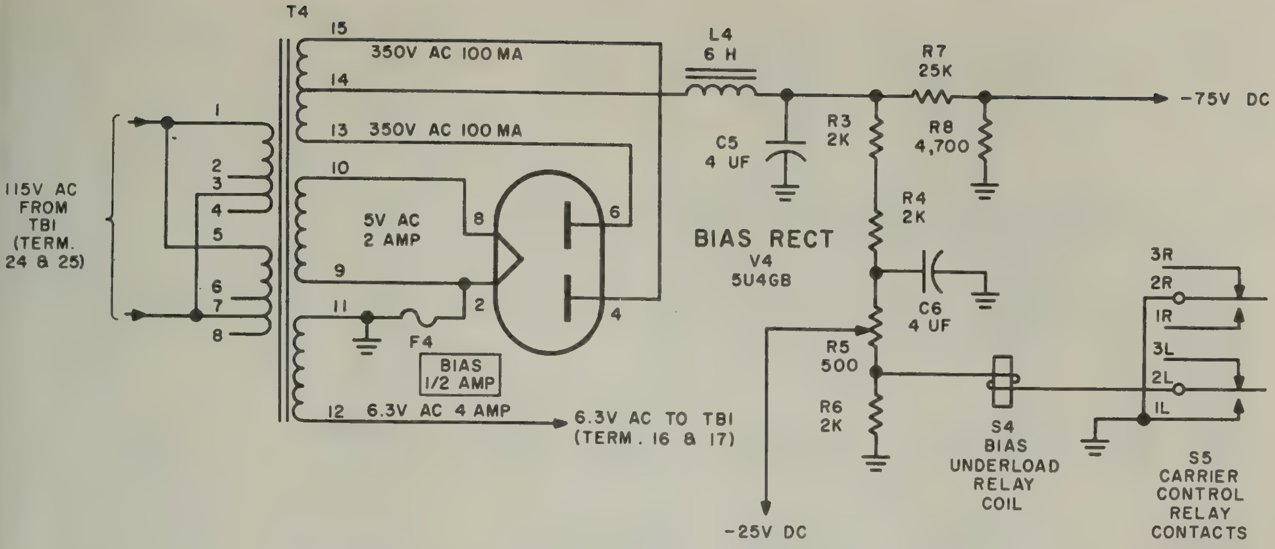


Figure 66. Bias rectifier V4, schematic diagram.

a. The 115 volts ac applied to the primary of transformer T2 is stepped down to 20 volts. The 20-volt ac line is connected through voltage adjusting control R9 to the rectifier. The output of the rectifier, filtered by capacitor C7, is adjusted by control R9 to +12 volts dc under load.

b. The +12 volts dc is used to energize carrier control relay S5, within the power supply, and is connected to output terminal 26 of terminal board TB1 to operate the simplex circuit and energize tone-voice relay O 208.

82. Bias Rectifier V4

(fig. 66)

A bias rectifier circuit is used to develop —75 and —25 volts dc to control the operation of the tubes in the transmitter. Tube V4 is a 5U4GB.

a. A voltage of 115 volts ac is applied to the primary of transformer T4. A center-tapped secondary winding furnishes 350 volts ac to rectifier V4.

b. The output is taken from the center tap of the plate winding of transformer T4 and is fed through a choke input filter, consisting of choke L4 and capacitors C5 and C6, to terminals 11 and 12 of terminal board TB1.

c. Two values of bias voltage are obtained from the bleeder-voltage divider network across the filter output. This network consists of resistors R3, R4, R5, and R6 connected in series and paralleled with resistors R7 and R8 in series. When the transmitter is keyed, carrier control relay S5 closes, and resistor R6 is shunted by the coil of bias underload relay S4. The adjustable tap on R5 is connected to output terminal 12 of terminal board TB1 and is adjusted to obtain —25 volts dc. A 75-volt dc output appears at the junction of R7 and R8 and is fed to output terminal 11 of TB1.

d. The filament of V4 is connected across the 5-volt winding of the transformer. Fuse F4 is an overload protection for the bias supply.

e. A 6.3-volt winding on the transformer is connected to terminal 17 of terminal board TB1 and furnishes filament voltage to the subcarrier section of the goniometer.

83. Control Circuits

(fig. 67)

Control circuits of Power Supply PP–1331/FRN–20 are designed to delay the application of ac power to the plate transformers until filaments are at operating temperature and to open the ac line to the plate transformers, if there is a bias supply failure.

a. Ac power at 115 volts is applied to terminals 24 and 25 of terminal board TB1 and through PRI FUSES F1 and F2. Switch S2 is normally left in the ON position. The ac power is applied to transformers T2 and T4, to the heater of thermal relay S3, and through terminals 13 and 15 on TB1 to the transmitter. When power is applied to transformers T2 and T4, the +12 volts dc and the bias voltage are available immediately.

b. Thermal relay S3 closes after 30 seconds and power is applied to plate supply transformers T1 and T3 through panel interlock switch S1 and

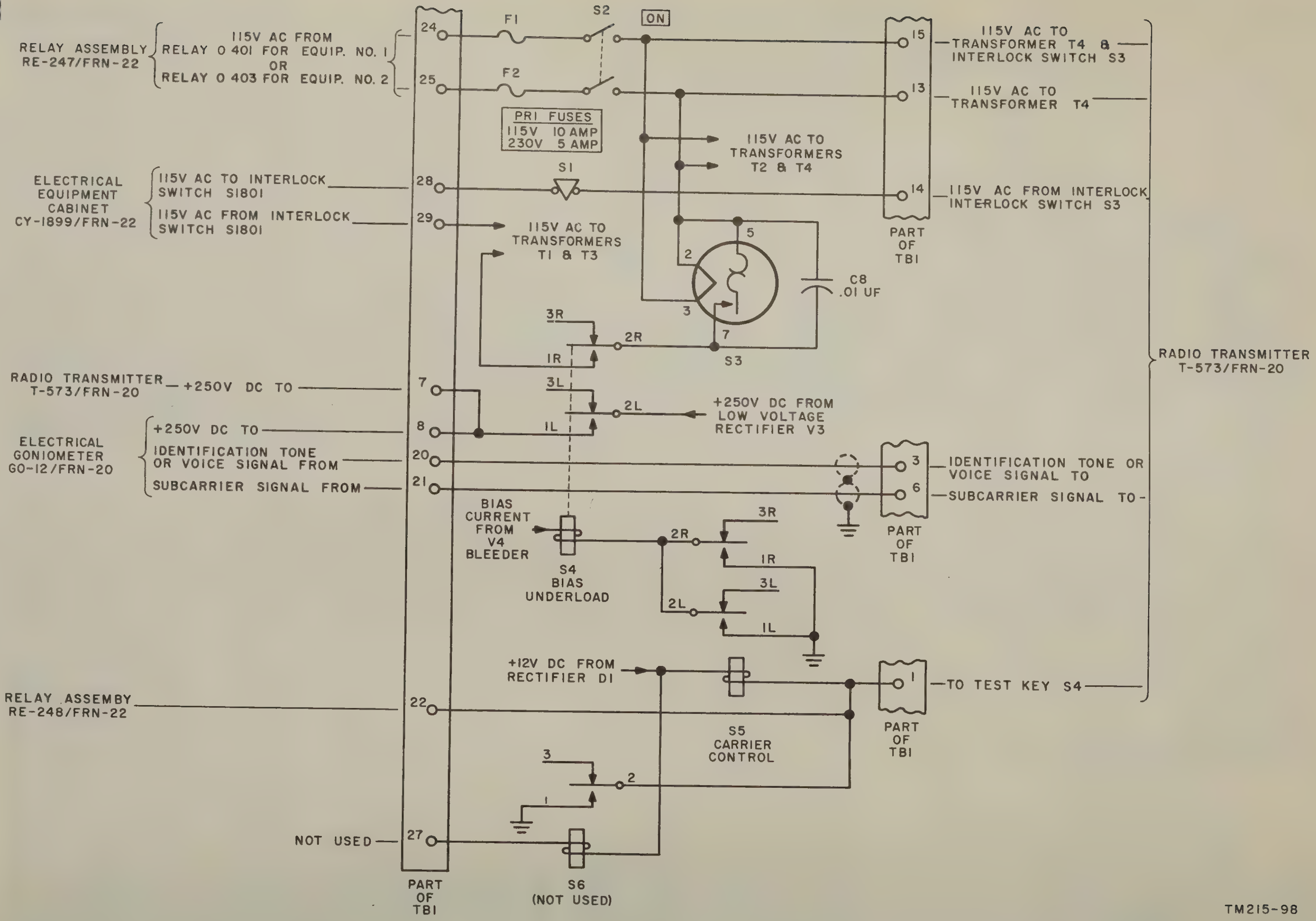


Figure 67. Control circuits, schematic diagram.

the energized contacts of bias underload relay S4.

c. Bias underload relay S4 is energized by current from the bias supply through the energized contacts of carrier control relay S5. Relay S5 is energized by the +12 volts dc from rectifier D1 when omni relay O 205 or O 302 (fig. 155) is energized by dialing or when TEST KEY S4 on the transmitter is pressed. Relay S5 can also be energized by the press-to-talk switch on the microphone after the transmitting equipment has been placed in a warmup condition.

d. One pair of contacts on relay S4 breaks the 250-volt output and the other pair breaks the 115-volt line to plate transformers T1 and T3. Keying relay S6 has no function in the omnirange set.

e. Two audio signals from the goniometer are carried through terminals 20 and 21 and terminals 3 and 6 on terminal board TB1 to the transmitter. Because these circuits are both above ground potential, only one wire is required to carry each of the two separate signals.

Section IV. THEORY OF MODULATION ELIMINATOR MX–1843/FRN–20

84. Block Diagram

(fig. 68)

The modulation eliminator receives a small part of the modulated RF carrier from the transmitter, removes the modulation, and amplifies the unmodulated carrier to the level required by the goniometer. For complete circuit details, refer to the overall schematic diagram (fig. 277).

a. The modulated RF carrier from the transmitter is coupled to carrier amplifier V1, amplified, and a portion of the modulation removed. The output is applied to envelope detector V3 and through a tuned pi network to the goniometer.

b. Tube V3 demodulates the carrier, and the audio portion is coupled to limiting amplifier V2.

c. Tube V2 amplifies the audio signal, and the output is fed back to carrier amplifier V1.

d. Dc operating voltages for the modulation eliminator are developed by rectifier V4.

e. A meter and meter-switching circuits are provided to check the voltages and currents in the modulation eliminator.

85. Carrier Amplifier V1

(fig. 69)

Carrier amplifier V1 uses a 6146 to amplify the RF carrier from the transmitter and to remove a portion of the modulation.

a. The modulated RF carrier is fed into the modulation eliminator through receptacle J2. Receptacle J1 is connected directly to receptacle J2 and the greater portion of the carrier passes out through receptacle J1 to the antenna. A small portion of the carrier is coupled to V1. Tube V1 operates as a moderately saturated class C amplifier. The time constant of coupling capacitor C1 and grid resistor R1 is sufficiently short so that grid bias developed by grid current flowing through R1 will vary proportionately to the modulation envelope, thereby limiting the audio variations in the output. The input signal is of sufficient amplitude to drive V1 into saturation and cause clipping of the audio signal peaks.

b. Most of the output is coupled to a tuned pi network through capacitor C5. A small portion of the RF signal is coupled through capacitor

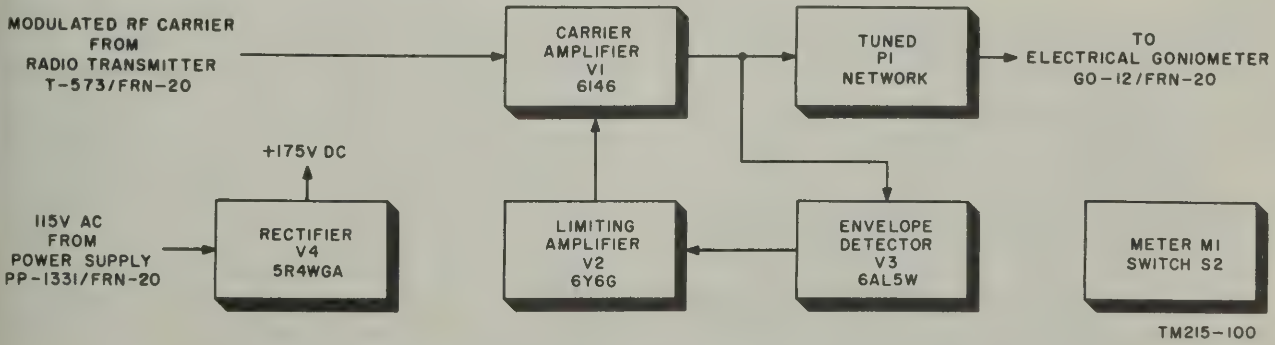

MODULATED RF CARRIER FROM RADIO TRANSMITTER T-573/FRN-20
CARRIER AMPLIFIER V1 6146
TUNED PI NETWORK
TO ELECTRICAL GONIOMETER GO-12/FRN-20
+175V DC
115V AC FROM POWER SUPPLY PP-1331/FRN-20
RECTIFIER V4 5R4WGA
LIMITING AMPLIFIER V2 6Y6G
ENVELOPE DETECTOR V3 6AL5W
METER M1 SWITCH S2
TM215-100

Figure 68. Modulation Eliminator MX–1843/FRN–20, block diagram.

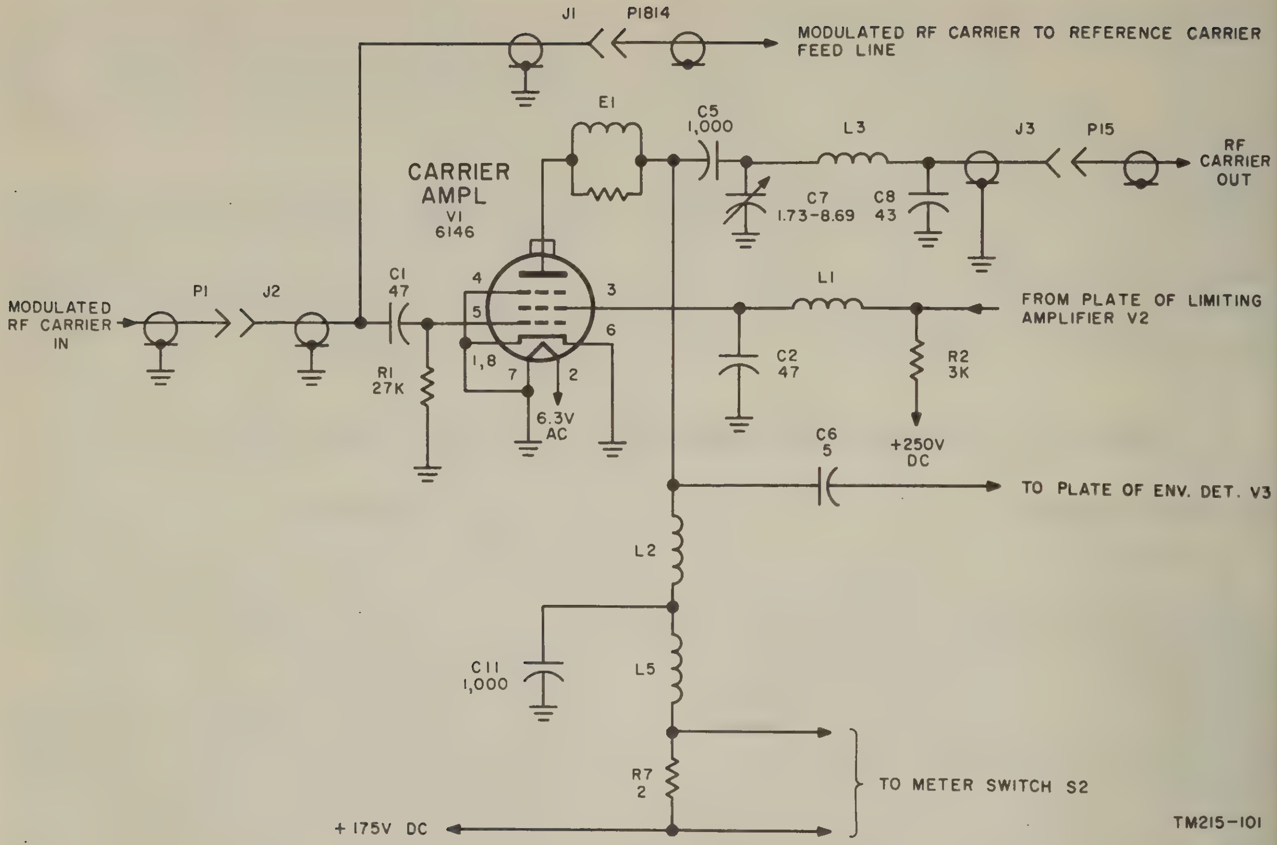


Figure 69. Carrier amplifier V1, schematic diagram.

C6 to envelope detector V3. The tuned pi network consists of variable capacitor C7, inductor L3, and capacitor C8. The network tunes to any frequency between 108 and 118 mc. Output of the network connects to 52-ohm coaxial receptacle J3. Parasitic suppressor E1 suppresses spurious oscillations.

c. Plate voltage for V1 is obtained from rectifier V4 through plate load inductor L2, decoupling inductor L5, and meter shunt resistor R7. Inductor L5 and capacitor C11 isolate the B+ supply from the RF voltages in the plate circuit of V1.

d. Screen voltage is obtained from rectified V4 through inductor L1 and resistor R2.

86. Envelope Detector V3

(fig. 70)

Envelope detector V3 uses one-half of a 6AL5W dual diode to demodulate the signal from V1.

a. A small portion of the RF signal is coupled through capacitor C6 to the plate of V3. Inductor L4 is the input load for V3.

b. The positive half-cycle of the modulation envelope is developed in the cathode circuit across load resistor R5 in series with metering resistor R10. Capacitor C9 filters the RF signal from the output of V3.

87. Limiting Amplifier V2

(fig. 71)

Limiting amplifier V2 uses a 6Y6G tetrode, connected as a triode, to amplify the audio signal from V3.

a. The audio signal from V3 is coupled through capacitor C4 to the control grid of V2. The audio signal in the plate circuit of tube V2 is inverted, because of normal vacuum tube characteristics, and is applied to the screen grid of V1 through inductor L1. The inverted audio signal causes degeneration in V1, thereby removing the remaining modulation of the RF carrier. Inductor L1 offers a high impedance to RF signals that might remain in the plate circuit of V2.

b. Self-bias is developed across the series arrangement of cathode resistor R3, SIDE BAND LEVEL control R9, and meter shunt resistor R8.

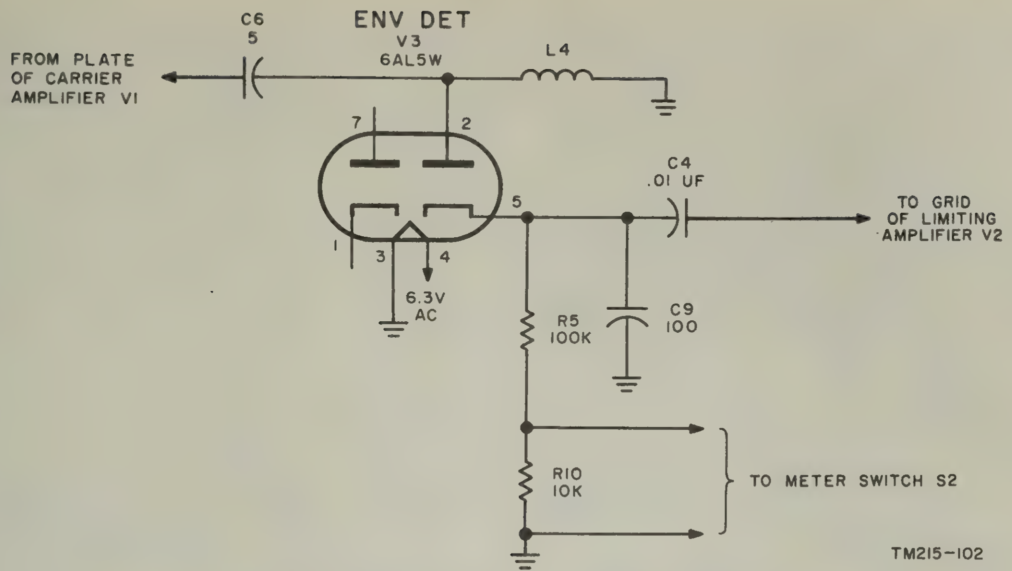


Figure 70. Envelope detector V3, schematic diagram.

The cathode is bypassed by capacitor C3. Resistor R4 is the grid load resistor. SIDE BAND LEVEL control R9 changes the bias of V2, thus increasing or decreasing the plate current. This action controls the output of the modulation eliminator by changing the screen voltage of carrier amplifier V1.

c. Plate voltage for V2 is obtained from rectifier V4 through plate load resistor R2.

88. Rectifier V4

(fig. 72)

Rectifier V4 uses a 5R4WGA full-wave rectifier to develop +175 volts dc for the plates and screens of the tubes in the modulation eliminator.

a. The 115 volts ac from receptacle J4 is applied to transformer T1 through fuse F1 and front panel interlock switch S1. A center-tapped high-voltage winding on T1 furnishes 275 volts ac to the plates of rectifier V4.

b. The high-voltage winding center tap is connected through the contacts of power relay K1 to ground when K1 is energized. Relay K1 is energized by —12 volts dc from the RE–248/FRN–22 when the omni relays are energized by dialing.

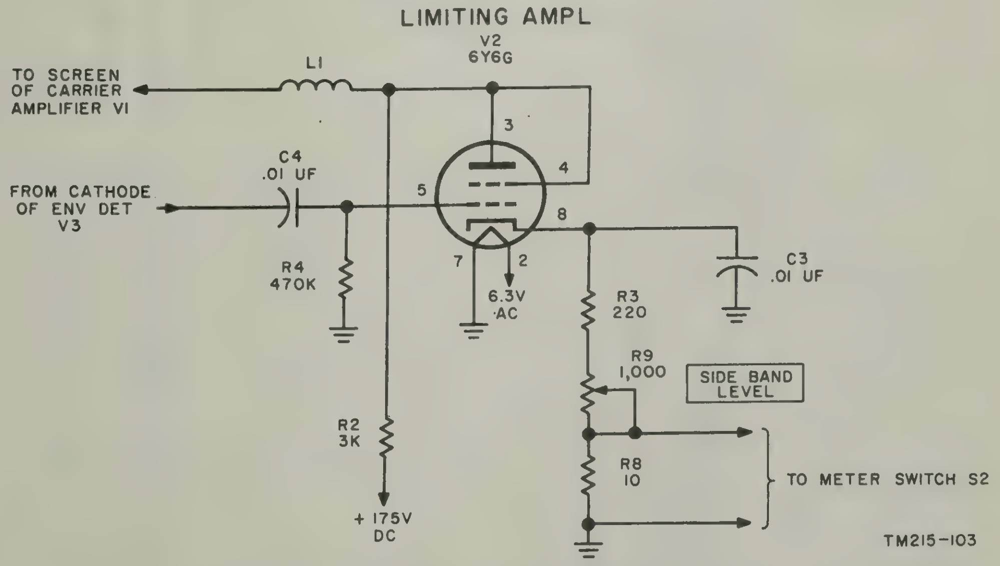


Figure 71. Limiting amplifier V2, schematic diagram.

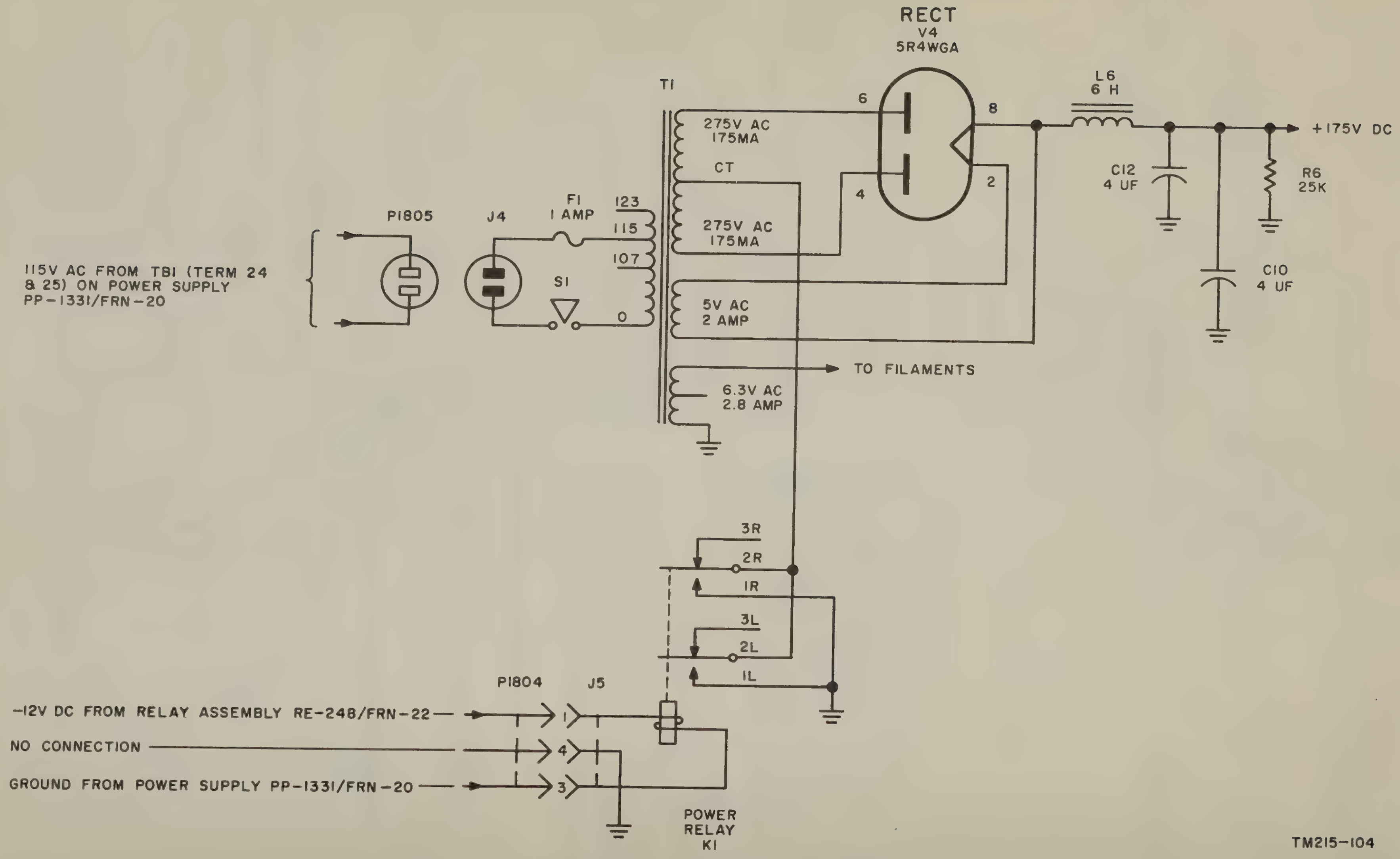


Figure 72. Rectifier V4, schematic diagram.

c. The output of V4 is filtered by a choke input filter consisting of choke L6 and capacitors C10 and C12. Resistor R6 furnishes the necessary bleeder current and, for safety, provides a discharge path for capacitors C10 and C12 when the modulation eliminator is turned off. Filament voltage for V4 is supplied by a 5-volt winding on T1. Filament voltage for V1, V2, and V3 is supplied by a 6.3-volt winding on transformer T1.

89. Meter Circuits

(fig. 73)

Metering is accomplished by meter M1, three-position meter switch S2, and either a current shunt resistor or a voltage multiplier resistor in the circuit to be metered. The full-scale range of meter M1 is 1 milliampere with an internal resistance of 1,000 ohms. Each shunt or multiplier resistor is connected to a pair of contacts on the switch.

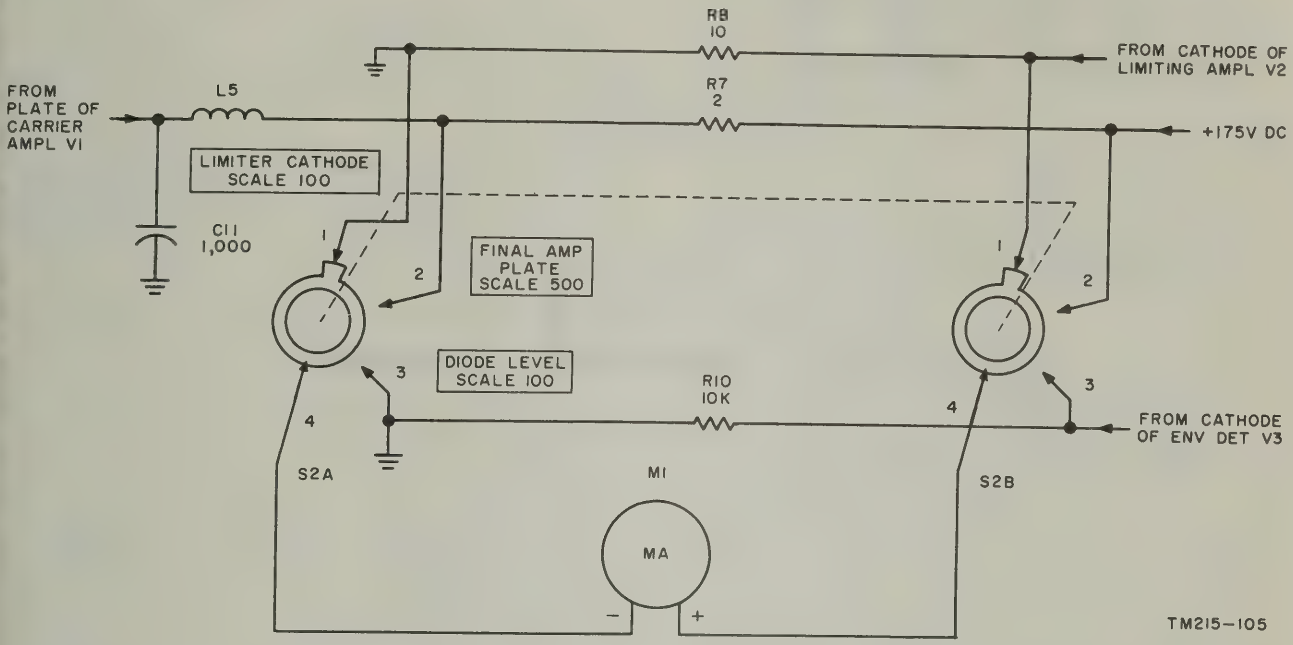

R8
10
FROM CATHODE OF LIMITING AMPL V2
FROM PLATE OF CARRIER AMPL V1
L5
R7
2
+175V DC
LIMITER CATHODE SCALE 100
C11
1,000
1
2
FINAL AMP PLATE SCALE 500
1
2
DIODE LEVEL SCALE 100
3
R10
10K
3
4
4
FROM CATHODE OF ENV DET V3
S2A
M1
S2B
MA
−
+
TM215—105

Figure 73. Meter circuits, schematic diagram.

Section V. THEORY OF ELECTRICAL GONIOMETER GO–12/FRN–20

90. Block Diagram

(fig. 74)

The goniometer couples the unmodulated RF output of the modulation eliminator to the variable sections of the antenna and develops a frequency-modulated subcarrier that amplitude-modulates the transmitter for reference carrier output. The goniometer also provides level adjustment and mixing of the subcarrier and identification signals or the subcarrier and voice-modulating signals before they modulate the transmitter. For complete circuit details, refer to the overall schematic diagram (fig. 278).

a. Goniometer capacitor C17 receives unmodulated RF power from the modulation eliminator through a balun matching transformer. Two RF outputs from capacitor C17 are fed through balun matching transformers to the two variable carrier sections of the antenna. The goniometer capacitor outputs vary in amplitude sinusoidally and reverse in polarity at a 30-cps rate. The 30-cps rate is produced by rotating capacitor C17 at 1,800 revolutions per minute (rpm). The two variable carrier sections of the antenna are physically displaced by 90°; therefore, the two outputs of the goniometer capacitor are electrically displaced by 90°.

b. The rotor of FM capacitor C18 is coupled to the shaft of goniometer capacitor C17 and varies the output frequency of swept oscillator V1B sinusoidally at the 30-cps rate.

c. Swept oscillator V1B has a center frequency of 200 kc and is swept 480 cps above and below

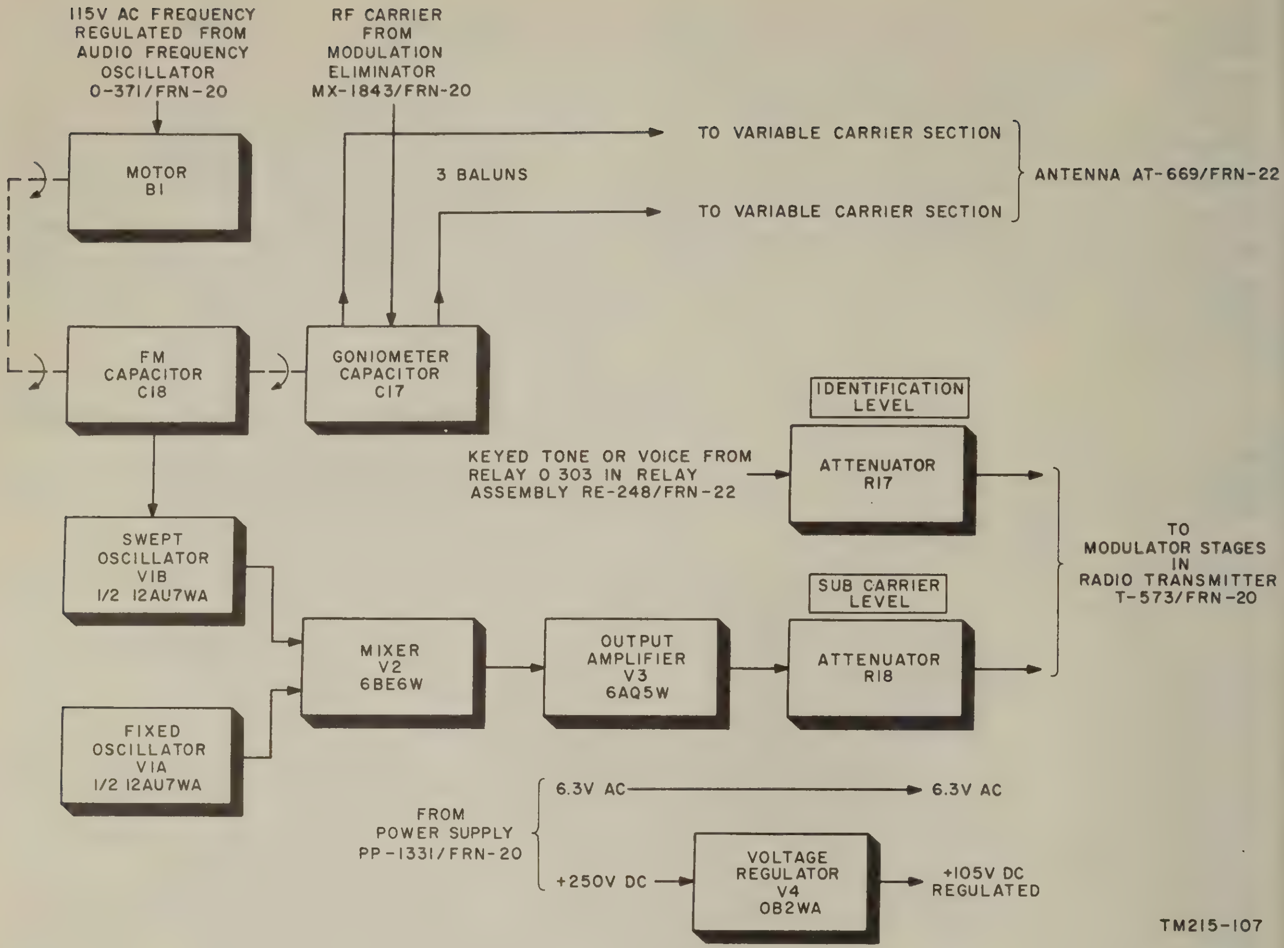

115V AC FREQUENCY REGULATED FROM AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
RF CARRIER FROM MODULATION ELIMINATOR MX-1843/FRN-20
TO VARIABLE CARRIER SECTION
3 BALUNS
TO VARIABLE CARRIER SECTION
ANTENNA AT-669/FRN-22
MOTOR B1
FM CAPACITOR C18
GONIOMETER CAPACITOR C17
IDENTIFICATION LEVEL
KEYED TONE OR VOICE FROM RELAY O 303 IN RELAY ASSEMBLY RE-248/FRN-22
ATTENUATOR R17
SWEPT OSCILLATOR V1B 1/2 12AU7WA
TO MODULATOR STAGES IN RADIO TRANSMITTER T-573/FRN-20
SUB CARRIER LEVEL
MIXER V2 6BE6W
OUTPUT AMPLIFIER V3 6AQ5W
ATTENUATOR R18
FIXED OSCILLATOR V1A 1/2 12AU7WA
6.3V AC
6.3V AC
FROM POWER SUPPLY PP-1331/FRN-20
+250V DC
VOLTAGE REGULATOR V4 0B2WA
+105V DC REGULATED
TM215-107

Figure 74. Electrical Goniometer GO-12/FRN-20, block diagram.

that center frequency by FM capacitor C18. The output of oscillator V1B sweeps between 199.520-200.480 kc sinusoidally at the 30-cps rate. The low impedance output is fed to one section of mixer tube V2.

d. Fixed oscillator V1A generates a signal frequency of 190.040 kc which is fed to the second section of mixer V2.

e. Mixer V2 combines the RF outputs of the swept oscillator and the fixed oscillator to produce the sum and difference frequencies in its output. The difference frequency is selected; it is the 9,960-cps FM subcarrier having a frequency deviation of 480 cps at a 30-cps rate.

f. The subcarrier output from mixer V2 is coupled to output amplifier V3. The low impedance output of V3 is fed to SUB CARRIER LEVEL attenuator R18.

g. The signal from V3 is applied to SUB CARRIER LEVEL attenuator R18 to provide a means of adjusting the subcarrier modulation level to 30 percent. The FM subcarrier amplitude-modulates the transmitter and the transmitter output becomes the reference carrier.

h. IDENTIFICATION LEVEL attenuator R17 is used to adjust the modulation level of the voice or keyed tone signals to the transmitter. Attenuators R17 and R18 also provide a mixing network which presents a constant line impedance to the transmitter modulator.

i. Motor B1 is chain belt coupled to the common shaft of goniometer capacitor C17 and FM capacitor C18 and rotates these capacitors at 1,800 rpm. Frequency-regulated ac power at 115 volts is supplied to the motor by the O-371/FRN-20 and may have a frequency of 50 or 60 cps. The selection of the motor pulley size provides for the correct capacitor speed, which is determined by the synchronous motor speed.

j. The PP-1331/FRN-20 supplies 6.3 volts ac for filaments and +250 volts dc for plate voltages.

k. Voltage regulator V4 reduces the +250 volts dc and provides regulated +105 volts dc.

91. FM Capacitor C18, Goniometer Capacitor C17, and Motor B1

(figs. 75 and 76)

FM capacitor C18 is used to develop the FM subcarrier modulation for the transmitter, and goniometer capacitor C17 couples to the antenna the unmodulated RF power which varies sinusoidally in amplitude and polarity. Motor B1 rotates capacitors C17 and C18 at 1,800 rpm from a 115-volt 50- or 60-cycle source. The motor rotates in a counterclockwise direction when viewed from the pulley end.

a. FM capacitor C18 is a two-section variable tuning capacitor on a single shaft. The two stators are displaced physically by 180° and the interconnected rotors mesh equally with their respective stators at all positions of the common rotor shaft. The sections are positioned so that the rotor of one capacitor section does not mesh with the stator of the other section. The rotors are shaped to produce sinusoidal frequency variations. One stator of capacitor C18 is grounded and the other is connected to the tuned circuit of swept oscillator V1B.

b. Goniometer capacitor C17 is a three-section variable capacitor. Section C17B provides constant RF power coupling between balun T2 and capacitor sections C17A and C17C. The two capacitors of section C17B are identical, and each is made up of two disk-type stator plates surrounding one rotor plate. Balun T2 connects to the stator plates of the coupling capacitors. Sections C17A and C17C are made up of four identical variable capacitors. The two stators of each section are aligned so that the two rotors will mesh with either stator (fig. 76). The stators of section C17A are displaced 90° from the stators of section C17C. The rotors are paired on a common ceramic shaft so that one rotor of section C17A is connected to the rotor of section C17C, which is at the same position with respect to shaft rotation. Input RF power is applied to the paired rotors of sections C17A and C17C by the rotors of the coupling capacitors in section C17B. Because of the capacitance between paired rotor connections along the common shaft, a ring inductance has been placed in section C17B and connected between the rotor pair to cancel this undesirable capacitance. The stators of section C17A are connected to balun RF matching transformer T1, and the stators of section C17C are connected to balun T3. Equivalent circuits for the balun matching transformers are shown in figure 75.

c. In figures 75 and 76 the rotors of C17 have been assigned polarities and the stators have been numbered. The polarities are based upon the instantaneous polarities shown at the output of balun matching transformer T2. The amplitude and polarity of the voltage coupled to the rotors of C17 remain constant, regardless of rotor position. The equivalent circuits of baluns T1 and T3 are shown (fig. 76) with the stator plates of each section, C17A and C17C, effectively push-pull connected to their respective baluns. The waveforms in figure 76 are plots of relative voltage amplitude and polarity, referenced to ground. An example of calculating the output follows: The maximum voltage of output No. 2 occurs at 45°. If this voltage were 1 volt, the voltage at 90° would be 0.707 volt, neglecting losses. The outputs of any pair of stators cannot be added to produce the output No. 1 or No. 2 shown.

d. An azimuth plate (fig. 30), calibrated 0° through 360° on the goniometer capacitor housing is attached to the common rotor shaft. The azimuth plate indicates the relative position of the rotors with respect to the voltage curves of figure 76 and the actual bearing output of the variable carrier signal from the antenna. As shown, at 0° the positive voltage coupled to stator No. 1 is added to the negative voltage of stator No. 3 in matching transformer T1 and results in a positive voltage of 0.707 volt at output No. 1. At the same instant, the positive voltage coupled to stator No. 2 and added to the negative voltage of stator No. 4 results in a positive voltage of 0.707 volt at output No. 2. Therefore, at 0°, both variable carrier sections of the antenna are fed voltages of equal amplitude and polarity. At 45°, the combined voltages of stators No. 1 and No. 3 produce 1 volt at output No. 1, but the combined voltages of stators No. 2 and No. 4 result in zero voltage at output No. 2. At 45°, only one variable carrier section of the antenna is being excited. Rotation to 90° results in a positive voltage of 0.707 volt at output No. 1, but combining stator No. 2 and stator No. 4 voltages results in a negative voltage of 0.707 volt at output No. 2. At this time, one variable carrier section of the antenna is excited with a positive voltage

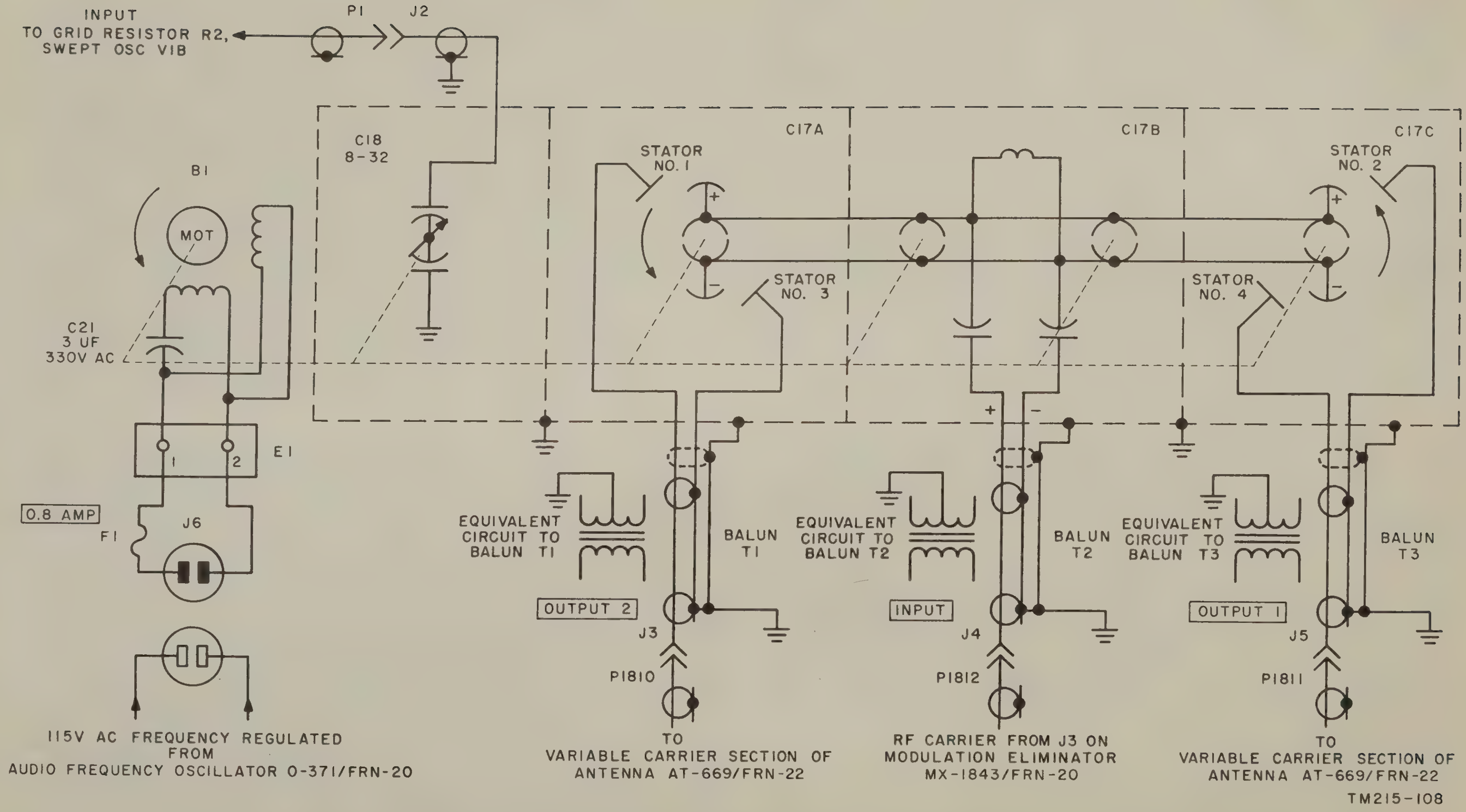

INPUT
TO GRID RESISTOR R2, SWEPT OSC VIB
P1
J2
C18
8-32
C17A
C17B
C17C
B1
MOT
STATOR NO. 1
STATOR NO. 2
STATOR NO. 3
STATOR NO. 4
C21
3 UF
330V AC
E1
1
2
0.8 AMP
F1
J6
EQUIVALENT CIRCUIT TO BALUN T1
BALUN T1
EQUIVALENT CIRCUIT TO BALUN T2
BALUN T2
EQUIVALENT CIRCUIT TO BALUN T3
BALUN T3
OUTPUT 2
INPUT
OUTPUT 1
J3
J4
J5
P1810
P1812
P1811
115V AC FREQUENCY REGULATED FROM AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
TO VARIABLE CARRIER SECTION OF ANTENNA AT-669/FRN-22
RF CARRIER FROM J3 ON MODULATION ELIMINATOR MX-1843/FRN-20
TO VARIABLE CARRIER SECTION OF ANTENNA AT-669/FRN-22
TM215-108

Figure 75. Motor, FM and goniometer capacitors, schematic diagram.

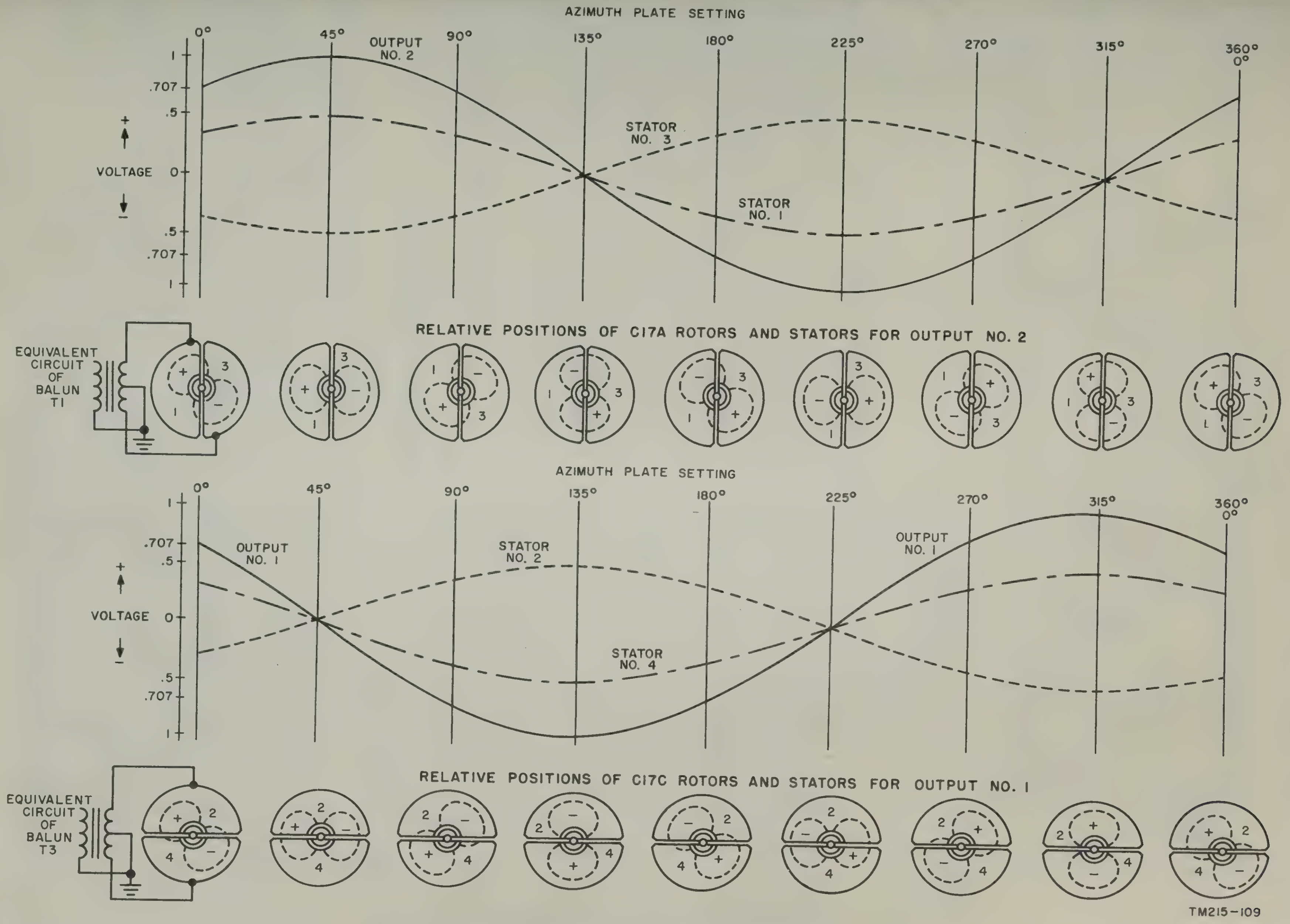


Figure 76. Output waveform vs. goniometer capacitor rotor position.

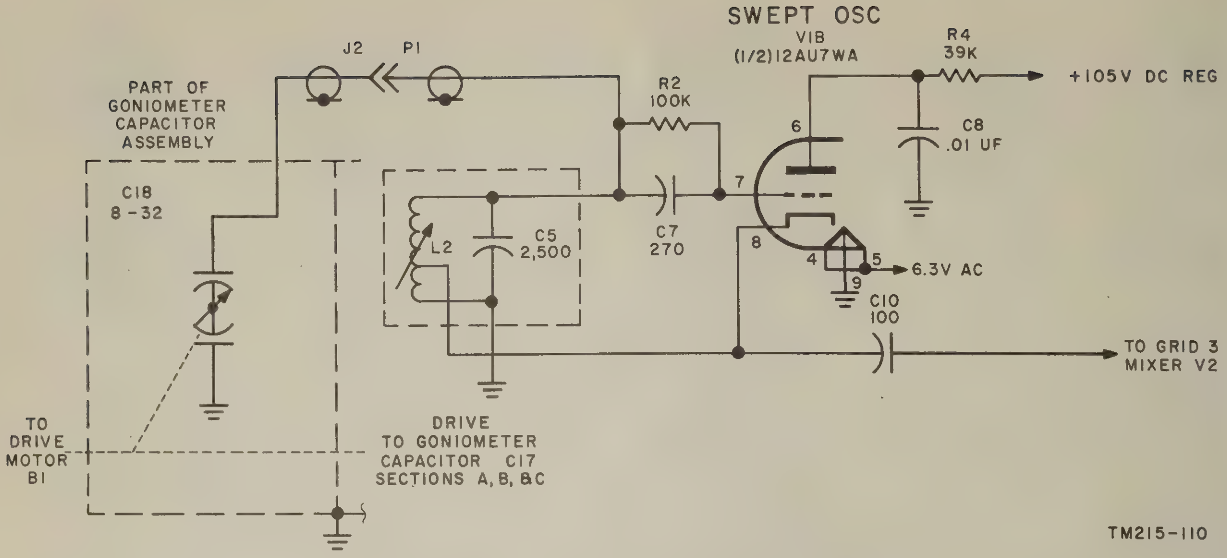


Figure 77. Swept oscillator V1B, schematic diagram.

while the other is excited with a negative voltage. Later discussion on the antenna (pars. 98–102) will show how these varying amplitudes and polarities produce the required bearing information.

e. Synchronous motor B1 rotates at 1,800 rpm on 60-cycle power or 1,500 rpm on 50-cycle power. The FM and goniometer capacitors are driven at 1,800 rpm by proper selection of motor pulleys. Ac power at 115 volts, 50 or 60 cps is supplied to motor B1 by AM–1247/FRN–20 and maintains the required 1,800 rpm speed of the FM and goniometer capacitors. Power connection to the motor is made through receptacle J6, fuse F1, and terminal board E1. Capacitor C21 shifts the phase of the input power to one of the two motor stator windings to give the motor the proper torque.

92. Swept Oscillator V1B

(fig. 77)

Tube V1B is one-half of a 12AU7WA dual triode connected in a grounded-plate Hartley oscillator circuit to produce a center frequency of 200 kilocycles (kc).

a. A parallel-tuned circuit consisting of inductor L2 and capacitor C5 is shunted by motor-driven FM capacitor C18 to produce a sinusoidal variation in frequency of 480 cycles above and below the center frequency of 200 kc. This frequency variation occurs at the 30-cps rotational rate of C18.

b. FM capacitor C18, located inside the FM and goniometer capacitor housing, is connected to the grid circuit of tube V1B through plug P1 and receptacle J2. The stators of C18 are rotatable a few degrees by fine course adjustment screw H1 (fig. 228). This adjustment is required to compensate for a slight installation misalinement of the antenna in relation to magnetic North.

c. Feedback to sustain oscillations is supplied by the cathode to the tap of inductor L2. Grid bias is developed by resistor R2 and capacitor C7.

d. Capacitor C8 maintains the plate at RF ground potential, and plate voltage is applied through resistor R4.

e. The signal output is coupled from the cathode to the input of mixer V2 through capacitor C10.

93. Fixed Oscillator V1A

(fig. 78)

Tube V1A is one-half of a 12AU7WA dual triode connected in a grounded-plate Hartley oscillator circuit to produce a signal of 190.040 kc.

a. A parallel-tuned circuit consisting of inductor L1 and capacitor C1 resonates at 190.040 kc. Oscillations are sustained by feedback from the cathode to a tap on inductor L1. Grid bias is developed by grid resistor R1 and capacitor C3.

b. Capacitor C4 maintains the plate at RF ground potential; regulated plate voltage is supplied through resistor R3.

c. The output is coupled to mixer V2 through capacitor C9.

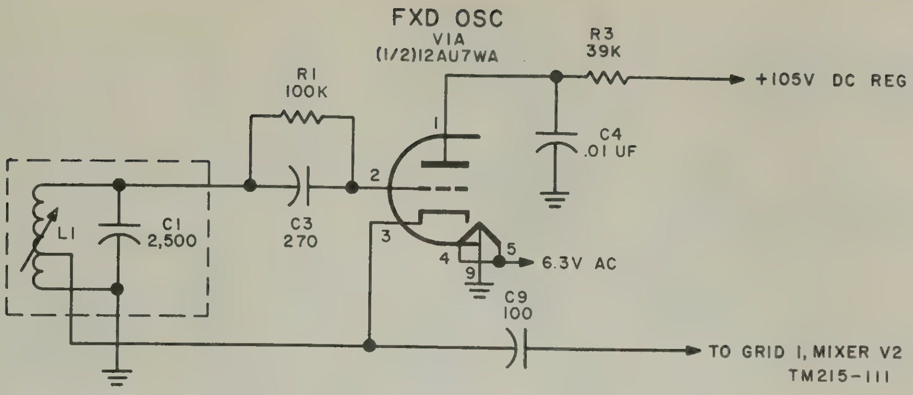


Figure 78. Fixed oscillator V1A, schematic diagram.

94. Mixer V2

(fig. 79)

A 6BE6W heptode is used as a mixer to combine the swept oscillator (V1B) and fixed oscillator (V1A) output signals and produce the difference frequency. The difference frequency is then coupled to output amplifier V3.

a. The FM signal from swept oscillator V1B is coupled through capacitor C10 to the injector grid (pin 7) of V2. The injector grid dc return is through resistor R6 to the junction of cathode bias resistors R8 and R7. This is done to apply a portion of the self-bias on V2 to the injector grid. The signal from fixed oscillator V1A is coupled through capacitor C9 to the control grid (pin 1) of V2 across grid dc return resistor R5. Capacitor C11 maintains the cathode at RF ground potential.

b. The sum and difference of the two input frequencies appear at the plate (pin 5) of V2. Inductor L3, resistors R10 and R11, and capacitors C12 and C13 form a low-pass filter which will pass only the difference frequency to coupling capacitor C14. The difference frequency, varying from 9,480 to 10,440 cps at a 30-cps rate, is the subcarrier signal and is coupled through capacitor C14 to output amplifier V3.

c. Plate voltage for V2 is obtained from voltage regulator V4 through plate load resistor R10. Screen-grid voltage is supplied by V4 through dropping resistor R9. Capacitor C19 maintains the screen grid at RF ground potential.

95. Output Amplifier V3

(fig. 80)

Output amplifier V3 is a 6AQ5W pentode connected as a triode cathode follower to provide a low impedance subcarrier signal input to attenuator R18. The subcarrier signal from mixer V2 is coupled through capacitor C14 to the control grid of V3 across grid dc return resistor R12. Capacitor C16 maintains the plate of tube V3 at RF ground potential. The dc plate voltage is

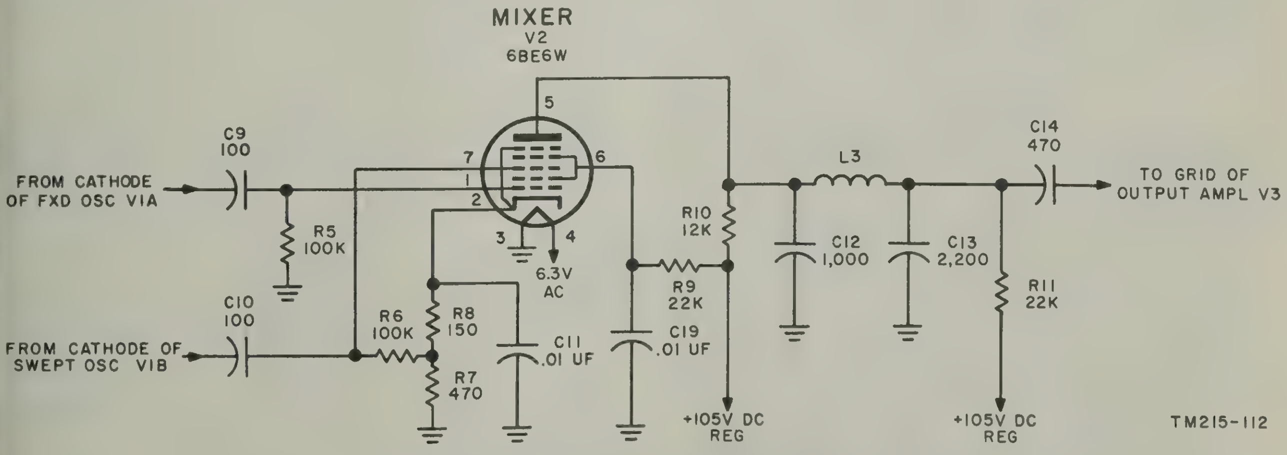


Figure 79. Mixer V2, schematic diagram.

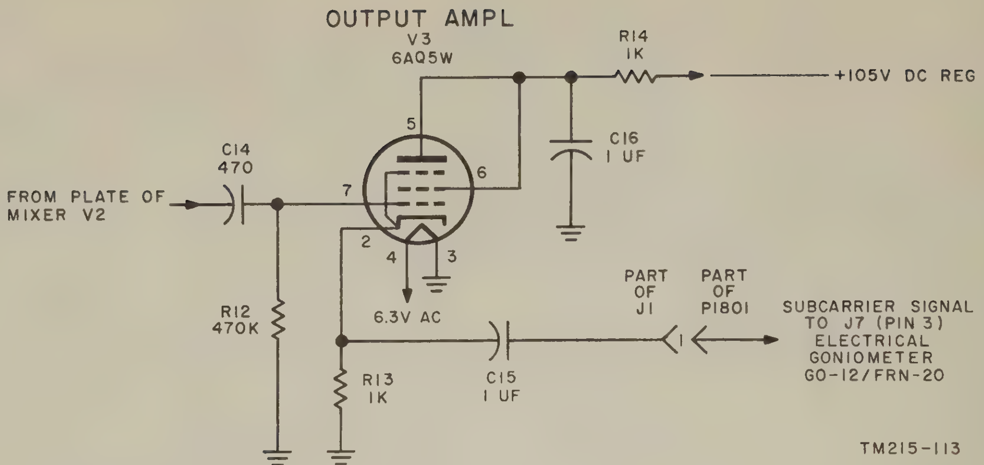


Figure 80. Output amplifier V3, schematic diagram.

supplied from voltage regulator V4 through resistor R14. The subcarrier output signal is developed across cathode-biasing resistor R13 and coupled through capacitor C15 to receptacle J1.

96. Voltage Regulator V4

(fig. 81)

Voltage regulator V4 provides regulated +105 volts dc for plate and screen grid requirements of the subcarrier sections. A potential of +250 volts dc from the PP-1331/FRN-20 is applied through connectors P1812 and J7 (pin 9) to a ripple filter consisting of reactor L4 and capacitor C20. The output of the ripple filter passes through connectors J7, P1812 (pin 10), P1801, J1 (pin 3), and voltage dropping resistor R15 to the regulated +105-volt dc bus. Voltage regulator V4 varies the current load through the dropping resistor to maintain +105 volts dc.

97. Attenuator R17 and R18

(fig. 82)

IDENTIFICATION LEVEL attenuator R17 and SUBCARRIER LEVEL attenuator R18 mix the identification, voice, and subcarrier signals into a common line to the transmitter modulator. The levels are adjusted to obtain the correct percentage of modulation.

a. Keyed tone or voice signals from RE-248/FRN-22 are fed through connectors P1812 and J7 (pin 1) to IDENTIFICATION LEVEL attenuator R17. The output of R17 passes through connectors J7 and P1812 (pin 7) to terminal board TB1 (terminal 20) of the PP-1331/FRN-20. The subcarrier signal from receptacle J1 of output amplifier V3 is fed through connectors P1812 and J7 (pin 3) to SUBCARRIER LEVEL attenuator R18. The output of R18

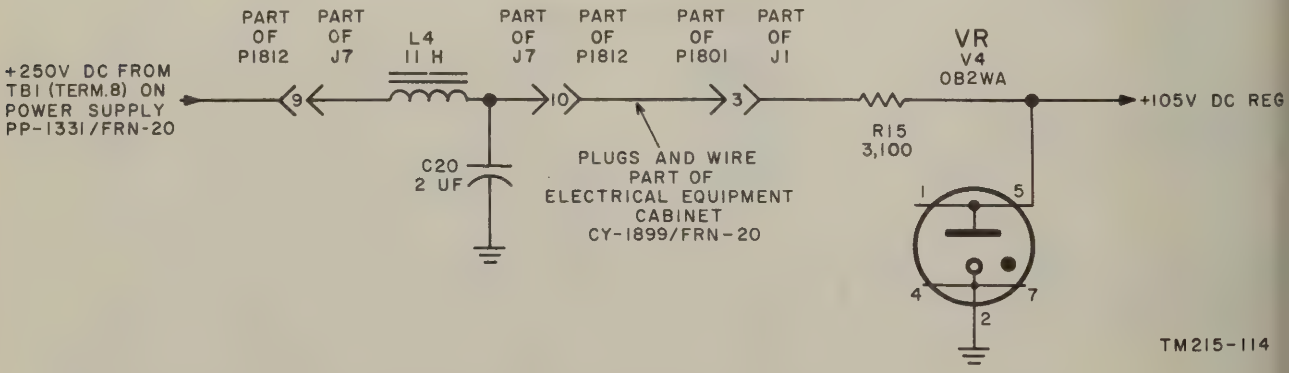


Figure 81. Voltage regulator V4, schematic diagram.

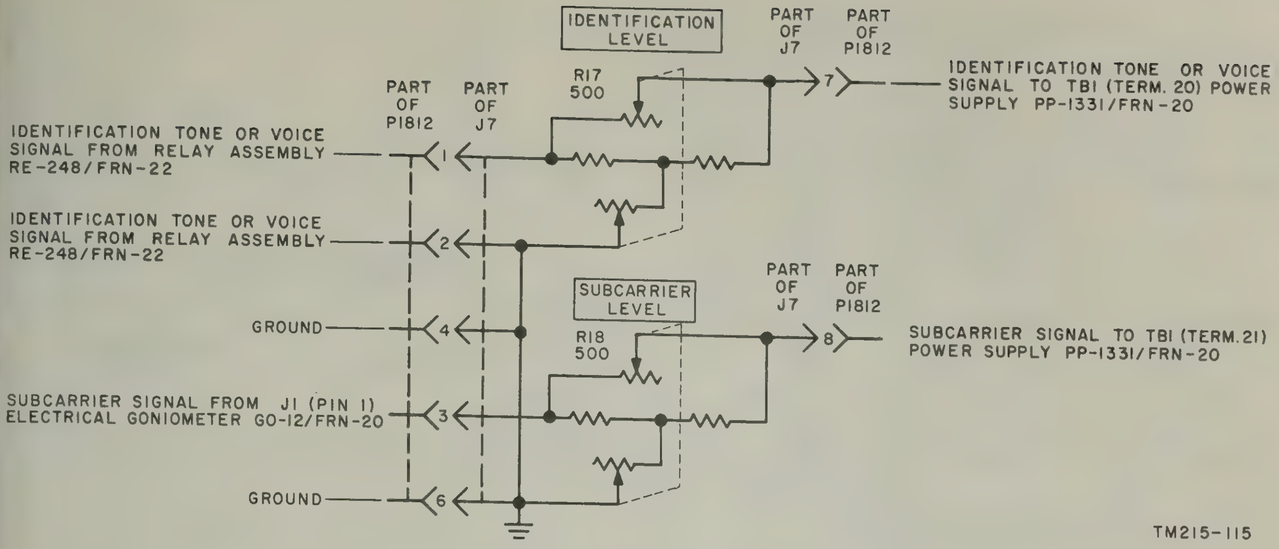

IDENTIFICATION LEVEL
PART OF J7
PART OF P1812
R17 500
IDENTIFICATION TONE OR VOICE SIGNAL TO TB1 (TERM. 20) POWER SUPPLY PP-1331/FRN-20
PART OF P1812
PART OF J7
IDENTIFICATION TONE OR VOICE SIGNAL FROM RELAY ASSEMBLY RE-248/FRN-22
IDENTIFICATION TONE OR VOICE SIGNAL FROM RELAY ASSEMBLY RE-248/FRN-22
SUBCARRIER LEVEL
PART OF J7
PART OF P1812
GROUND
R18 500
SUBCARRIER SIGNAL TO TB1 (TERM.21) POWER SUPPLY PP-1331/FRN-20
SUBCARRIER SIGNAL FROM J1 (PIN 1) ELECTRICAL GONIOMETER GO-12/FRN-20
GROUND
1
2
4
3
6
7
8
TM215-115

Figure 82. Attenuators R17 and R18, schematic diagram.

passes through connectors J7 and P1812 (pin 8) to terminal board TB1 (terminal 21) of the PP–1331/FRN–20.

b. The common output connection at the modulator of the transmitter is maintained at a constant impedance because increasing resistance of one ganged control section will decrease the resistance of the other proportionately.

c. For interunit theory of modulating circuits, refer to paragraphs 210 through 213.

Section VI. THEORY OF ANTENNA AT–669/FRN–22

98. General

(fig. 83)

The antenna is a four-slot cylindrical type that radiates a VHF omnirange signal consisting of a reference carrier and two variable carrier signals. The four equally spaced longitudinal slots in the wall of the cylindrical cavity are the radiating elements. The slots are excited by three independent feeder lines so that one circular radiation pattern and two figure-of-eight patterns are obtained. When the antenna is used with the goniometer, a rotating eccentric variable carrier lobe is produced which provides for space modulation and phase comparison with the reference carrier. The antenna is tunable from 108 to 118 mc. The shelter roof serves as a counterpoise for the antenna.

a. The four parallel slots, equally spaced around the metal cylinder, are designated northwest, northeast, southeast, and southwest. The slots have fins along the vertical edges which produce capacitive slot loading and support the adjustable bridge circuits. Small adjustable capacitors are across each slot to compensate for manufacturing tolerances in slot dimensions. The variable carrier internal feeder lines are inclosed in metal tubing and terminated on the antenna wall near the lower end of the slots. The reference carrier uses open feeder lines from the feed plate terminated at the upper end of the slots.

b. The antenna is centered and oriented so the black vertical mark and the letter "N," between the northeast and northwest slots, are facing magnetic North. The three antenna feed lines, the antenna heater cables, and the obstruction light cables are routed through the center tube of the antenna into the pedestal.

99. Antenna Slots and Slot Tuning

(fig. 84)

The four radiation slots of the antenna are approximately ½ wavelength long by 0.15 wavelength wide and are cross-connected by upper and lower reactance bridge circuits. Tuning adjustments of the slots are made by repositioning the bridge assemblies on inductive slot extensions and adjusting capacitor plungers.

a. The reactance bridges are identical and have adjustable inductive and capacitive elements

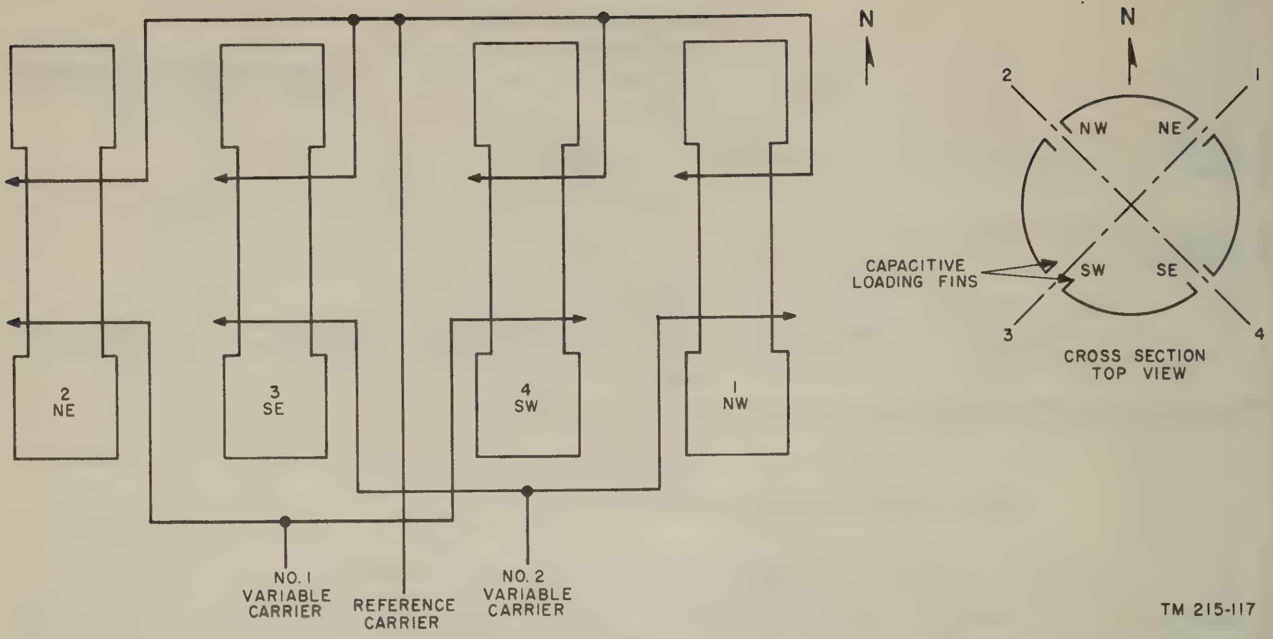


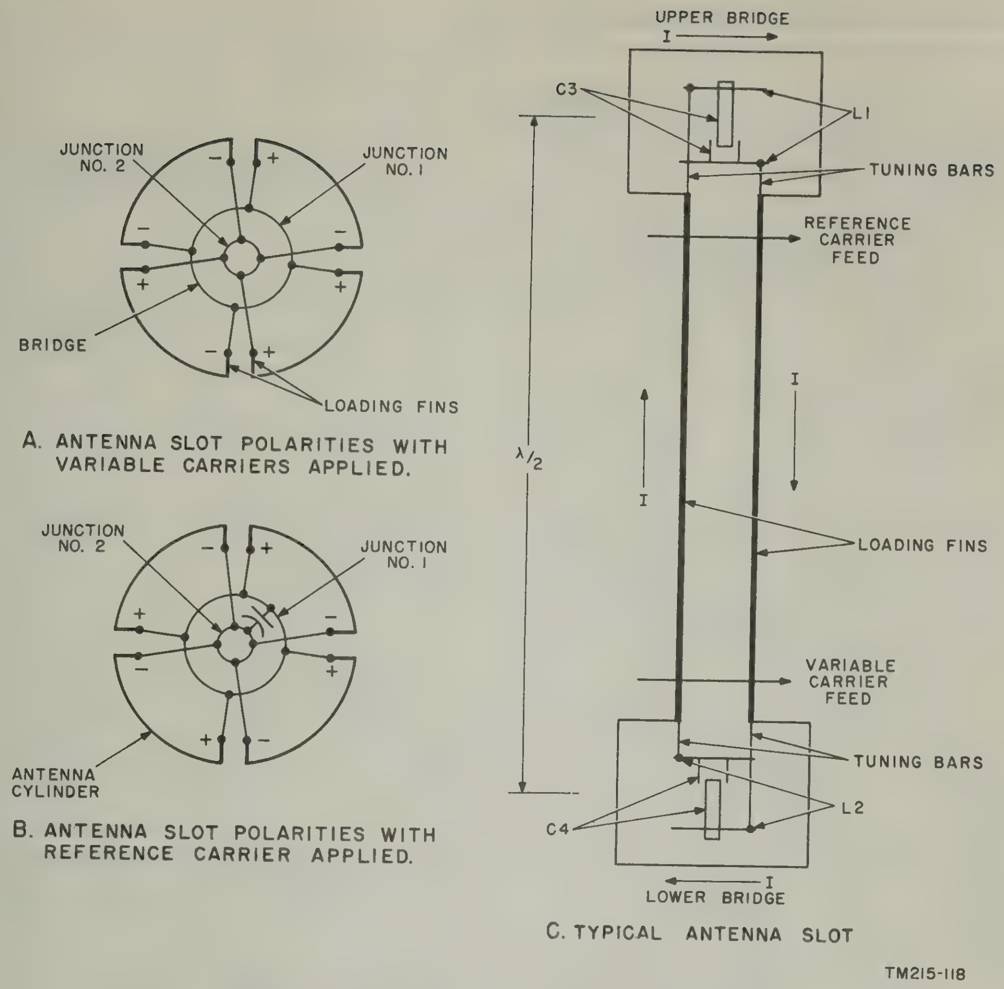
Figure 83. Antenna AT–669/FRN–22, slot locations and slot feed lines.

which may be adjusted without upsetting radiation symmetry. Inductive adjustment is made by sliding the complete bridge up or down on the tuning bars mounted at the ends of the loading fins. Capacitive adjustments are made by sliding the capacitor plunger in or out of the stator ring mounted in the bridge center. Both inductive and capacitive elements have graduated scales which are used with the tuning chart furnished with the antenna. Increasing inductance across the antenna slot effectively shortens the slot and raises the resonant frequency. Increasing the capacity across the antenna slot effectively lengthens the slot and lowers the resonant frequency. By cross-connecting opposite pairs of slots, the impedance between the opposite pairs is effectively placed across each slot. Because of the cross-connected impedance, characteristic antenna radiation symmetry is maintained at all frequencies when the antenna is properly resonated and the four slots have been tuned.

b. The antenna is tuned in two basic steps with only one carrier exciting the slots at a time. While the variable carrier is exciting the antenna, points of equal amplitude but opposite polarity are produced across diagonally opposite slots (A, fig. 84). Junctions No. 1 and No. 2 are at zero potential and the lengths of the cross-connected conductors determine the value of inductance shunted across the slots. The length of the conductors is adjusted by sliding the bridge assemblies up or down on the slot extensions. Sliding the bridges away from the slot fins raises the resonant frequent of the slot.

c. When the reference carrier is exciting the antenna, the lengths of the cross-connecting conductors is immaterial because they cross-connect slot fins of equal amplitude and polarity (B, fig. 84). Junctions No. 1 and No. 2 are at a difference of potential, and a change in capacity across these two junctions will be reflected across the slots. Increasing capacity will effectively lengthen the slots and lower their resonant frequency. Thus, there are two independent antenna tuning adjustments; locating the bridges on the slot extensions during variable carrier excitation and the adjustment of capacitors C3 and C4 during reference carrier excitation. In actual practice, the bridges are positioned on graduated scales from the tuning chart furnished with the antenna; minor adjustments are made at the lower bridge if necessary.

d. When a potential is applied across a slot through a coaxial line, current flows around the slot (C, fig. 84). If the slot is relatively narrow in terms of wavelength, vertically polarized radiation caused by the vertical portions of the currents around the slot cancel. Horizontally polarized radiation is the only radiation from the slot and is produced by the horizontal portions of the current around the slot. Vertical polarization (par. 101) is undesirable in omnirange signals.



A. ANTENNA SLOT POLARITIES WITH VARIABLE CARRIERS APPLIED.

B. ANTENNA SLOT POLARITIES WITH REFERENCE CARRIER APPLIED.

C. TYPICAL ANTENNA SLOT

Figure 84. Antenna slot tuning, schematic diagram.

100. Feed Lines and Feed Line Tuning

(fig. 85)

Three feed lines are used to couple the RF power from the shelter to the antenna. The feed lines maintain complete isolating between the two variable carrier outputs and the reference carrier output, while performing impedance matching functions. Correct slot excitation polarities and cancellation of undesirable reactive components of the slots are obtained by specific feed line sections. Each of the three coaxial feed lines therefore presents to the transmitter and modulation eliminator a resistive load of 50 ohms.

a. The four antenna slots are excited by the reference carrier with four 200-ohm open wire transmission lines, which terminate near the upper end of each slot. Each slot termination is on the antenna wall adjacent to the point at which the loading fins attach. Each feed line excites the slot in the same direction and uses the antenna wall as the return path for the excitation. Because the slots are excited identically, a continuous field is produced around the antenna and an omnidirectional pattern radiated. The four 200-ohm lines are approximately one-quarter wavelength long and join at the center of the antenna. At this center point, a 50-ohm coaxial cable is attached and is routed out of the antenna to the reference carrier output of the transmitter. A small capacitor is formed between the junction of the four open wire lines and the plate to which the coaxial cable connects. The small capacitive reactance presented by this capacitor cancels the inductive reactance present at the junction. This cancellation results in a purely resistive feed point with a very low standing wave ratio on the feed line from the transmitter.

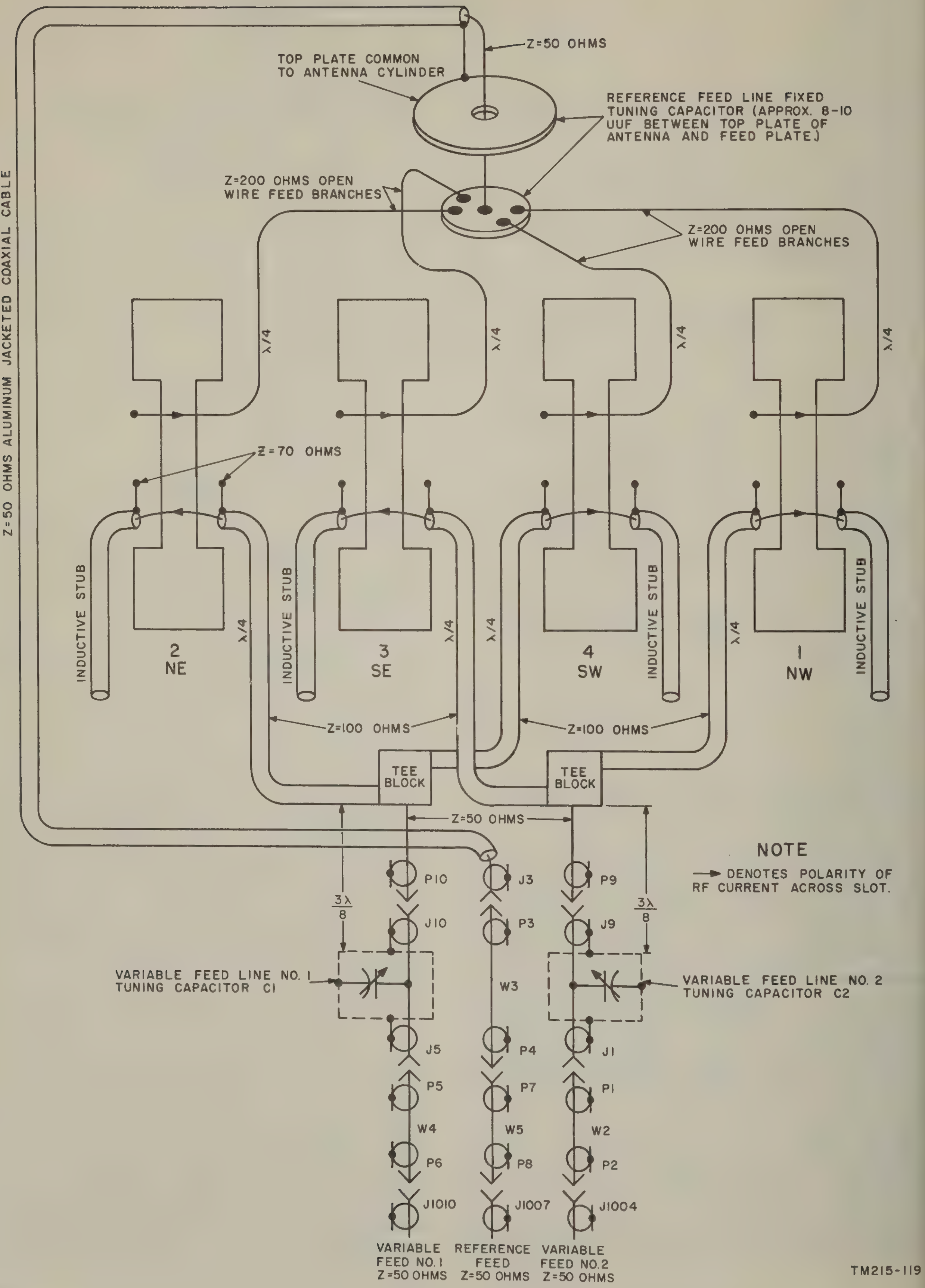

Z=50 OHMS ALUMINUM JACKETED COAXIAL CABLE
Z=50 OHMS
TOP PLATE COMMON TO ANTENNA CYLINDER
REFERENCE FEED LINE FIXED TUNING CAPACITOR (APPROX. 8-10 UUF BETWEEN TOP PLATE OF ANTENNA AND FEED PLATE)
Z=200 OHMS OPEN WIRE FEED BRANCHES
Z=200 OHMS OPEN WIRE FEED BRANCHES
λ/4
λ/4
λ/4
λ/4
Z=70 OHMS
INDUCTIVE STUB
2
NE
λ/4
INDUCTIVE STUB
3
SE
λ/4
λ/4
4
SW
INDUCTIVE STUB
λ/4
1
NW
INDUCTIVE STUB
Z=100 OHMS
Z=100 OHMS
TEE BLOCK
TEE BLOCK
Z=50 OHMS
NOTE
DENOTES POLARITY OF RF CURRENT ACROSS SLOT.
3λ/8
3λ/8
P10
J3
P9
J10
P3
J9
VARIABLE FEED LINE NO. 1 TUNING CAPACITOR C1
W3
VARIABLE FEED LINE NO. 2 TUNING CAPACITOR C2
J5
P4
J1
P5
P7
P1
W4
W5
W2
P6
P8
P2
J1010
J1007
J1004
VARIABLE FEED NO. 1 Z=50 OHMS
REFERENCE FEED Z=50 OHMS
VARIABLE FEED NO. 2 Z=50 OHMS
TM215-119

Figure 85. Feed points and feed line tuning diagram.

b. The four resonant antenna slots have an individual impedance of approximately 70 ohms and considerable capacitive reactance because of the loading fins. Each variable carrier feed line is a 50-ohm coaxial line, and the two systems are identical in construction. Therefore, the following discussion for variable carrier output No. 1 will also apply to output No. 2, except that the RF energy in them is 90° out of phase. The two coaxial lines feeding one pair of slots with variable carrier power are not connected directly across the slots. The outer conductor connects to the antenna wall adjacent to the lower end of the slot, and the inner conductor crosses the slot and joins the inner conductor of a coaxial stub. By connecting the outer conductor of the stub to the antenna wall on the opposite side of the slot with the far end shorted, the stub is effectively in series with the coaxial feed line to the antenna slot. The coaxial stub is less than one-quarter wavelength long and inductive. The stub length is cut to reflect the correct inductive reactance to cancel the capacitive reactance of the antenna slot. The two coaxial cables feeding the two antenna slots are approximately one-quarter wavelength long between the tee block and the slot. Each line has a characteristic impedance of 100 ohms and converts the 70-ohm slot resistance to 150 ohms. Paralleling the two 150-ohm ends in the tee block produces a 75-ohm resistive value at a common input terminal in the tee block. The tee block is effectively feeding RF power into the center of a coaxial line, which is one-half wavelength long and connected between diagonally opposite antenna slots. The polarities of energy at the ends of a line one-half wavelength long are reversed and therefore the polarities of the slots are reversed.

c. The impedance output of the modulation eliminator is 50 ohms, and the impedance of the tee block common input is 75 ohms. To match these two impedances, a 50-ohm coaxial line three-eighths wavelength long is connected to the common input of the tee block. The other end of the line is terminated in a capacitor box. Capacitor C1 (C2 for line No. 2) is shunted across the line to cancel the inherent inductive reactance of a three-eights wavelength line. Therefore the input impedance is purely resistive and matched to the 50-ohm feed line from the modulation eliminator.

101. Radiation Patterns

(figs. 86–88)

The radiation pattern from the antenna is the result of an omnidirectional reference carrier and a clockwise-rotating eccentric lobe, produced by the variable carrier. The reference carrier is the reference signal with which the rotational position (phase) of the variable carrier is compared at a specific instant (fig. 87). The eccentric variable carrier lobe is produced by vector addition of the reference carrier omnidirectional pattern and the two variable carrier figure-of-eight patterns at a specific time. The specific time is measured in degrees of arc from magnetic North clockwise. The eccentric variable carrier lobe rotates at the 30-cps rate, and the point of azimuth at which the resulting vector maximum falls, at a specific instant, is known as a radial. All radials are referenced to magnetic North regardless of antenna geographic location.

a. Vertically polarized radiation is undesirable (par. 99*d*) and is held to a minimum by the slot dimensions of the antenna. Also, the size of the counterpoise under the antenna and the distance of the counterpoise from the antenna govern vertical radiation. The shelter has been designed and positioned to reflect as small a vertical radiation component as is practicable. Any vertical radiation, mixed with horizontal radiation, will be slightly out of phase with the horizontal radiation at the receiving antenna and will cause bearing errors. These errors will be more pronounced close to the station and vary with the receiving antenna altitude and attitude. The cone of confusion, which indicates over-the-station position to the pilot, will be extremely erratic when too much vertically polarized radiation exists. To help prevent this, the overall design has reduced the vertical radiation to a negligible minimum and produces only horizontally polarized radiation fields.

b. The reference carrier radiation pattern is horizontally polarized and circular with the antenna at the center (fig. 88). Because all antenna slots are excited equally and in the same polarity, the phase of the reference carrier radiation pattern is the same at any point of azimuth around the antenna. The field strength at a given distance from the antenna is also the same at any point of azimuth around the antenna.

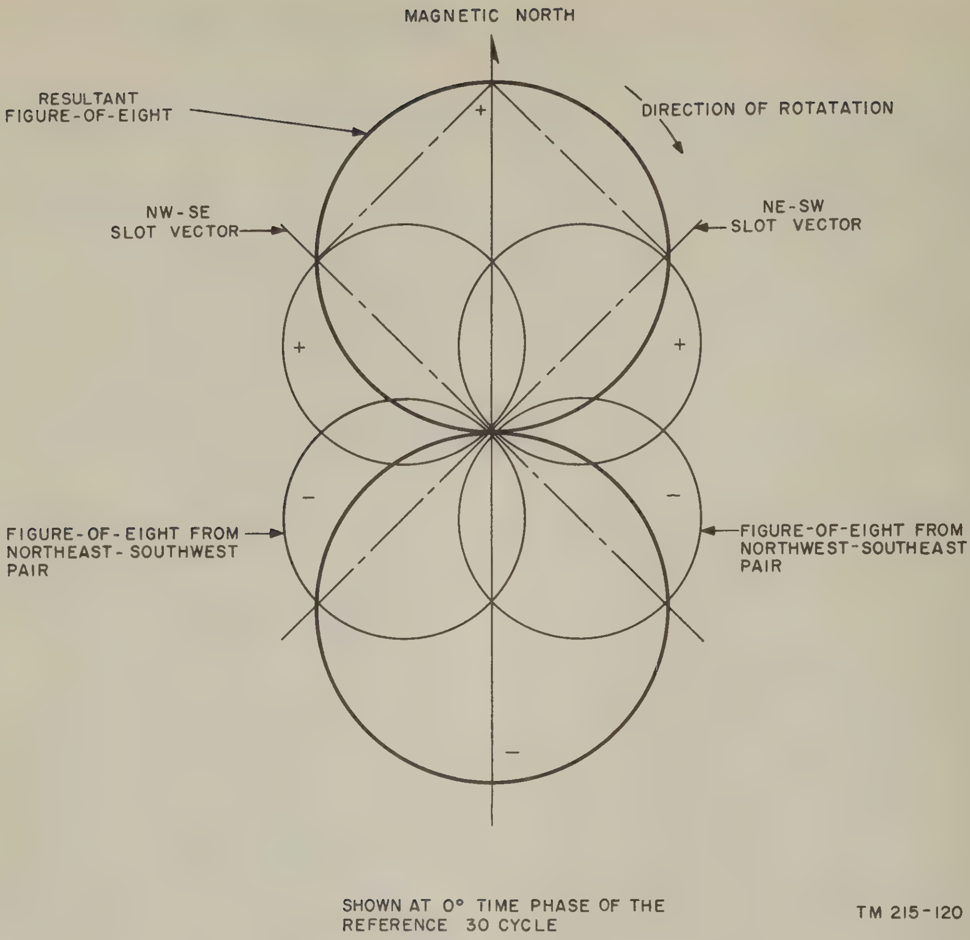

MAGNETIC NORTH
RESULTANT FIGURE-OF-EIGHT
DIRECTION OF ROTATATION
NW-SE SLOT VECTOR
NE-SW SLOT VECTOR
+
+
+
−
−
−
FIGURE-OF-EIGHT FROM NORTHEAST-SOUTHWEST PAIR
FIGURE-OF-EIGHT FROM NORTHWEST-SOUTHEAST PAIR
SHOWN AT 0° TIME PHASE OF THE REFERENCE 30 CYCLE
TM 215-120

Figure 86. Antenna AT–669/FRN–22, figure-of-eight radiation pattern.

c. The two variable carriers, displaced electrically by 90°, excite pairs of antenna slots which are displaced physically by 90° (fig. 86). Variable carrier No. 1 excites the northwest/southeast slots, and No. 2 the northeast/southwest slots. This displacement configuration does not change physically at any time. The figure-of-eight radiation patterns produced by the slot pairs take the form of two diagonally opposite circular fields of opposite radiation polarity. The magnitude, or field strength, of the polarized fields varies from zero to a fixed maximum, and the polarity reverses. These changes are controlled by the output delivered to the slot pair by the goniometer. When equal power and like polarities are fed to the antenna slots from the goniometer, the radiation pattern shown in figure 86 is produced (no reference carrier input). By vector addition, a resultant figure-of-eight pattern is produced. The individual slot lobes add to produce one resultant north and south figure-of-eight pattern.

d. Rotation is supplied to the resultant figure-of-eight radiation pattern by varying the amplitude and polarity relationship between the two antenna slot pairs. In A, figure 87, the northwest/southeast slots are receiving maximum excitation while the northeast/southwest are at zero excitation. This places the resultant lobe at 315°. However, the excitation to the northwest/southeast slots has been reduced, but the excitation to the northeast/southwest slots is increasing. The resultant radiation pattern has moved to 337.5°. C in figure 87 duplicates figure 86 and results in movement to 0°. Progressing from 315° through 45°, the northwest and northeast minor lobes were all positive, and amplitude variations produced rotation. In F, figure 87, the polarity of the northwest/southeast fields have reversed, but because of their low amplitude in comparison to the northeast/southwest fields, the resultant radiation pattern moves smoothly to 67.5°. Thus, figure 86 indicates the method by which the resultant radiation pattern

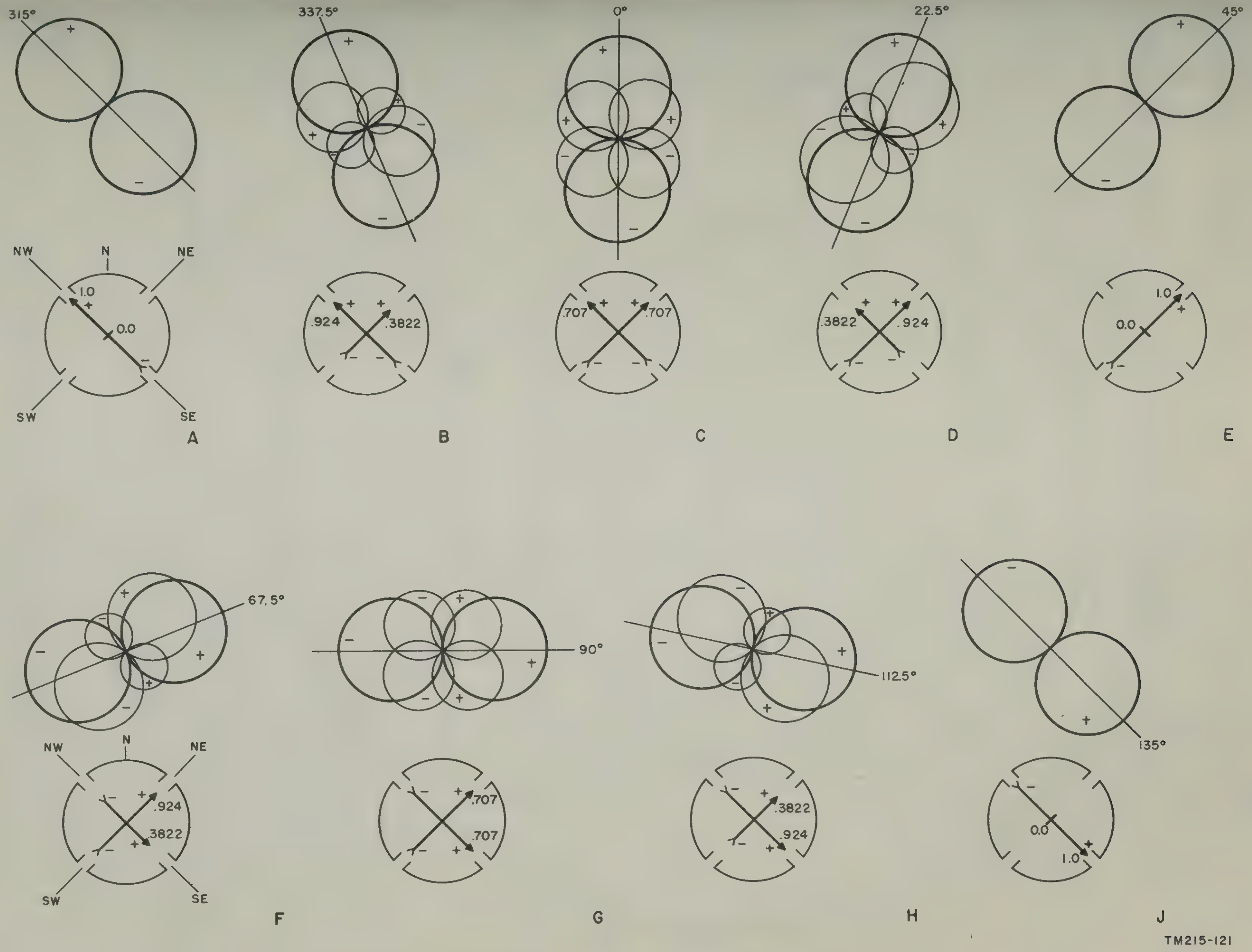
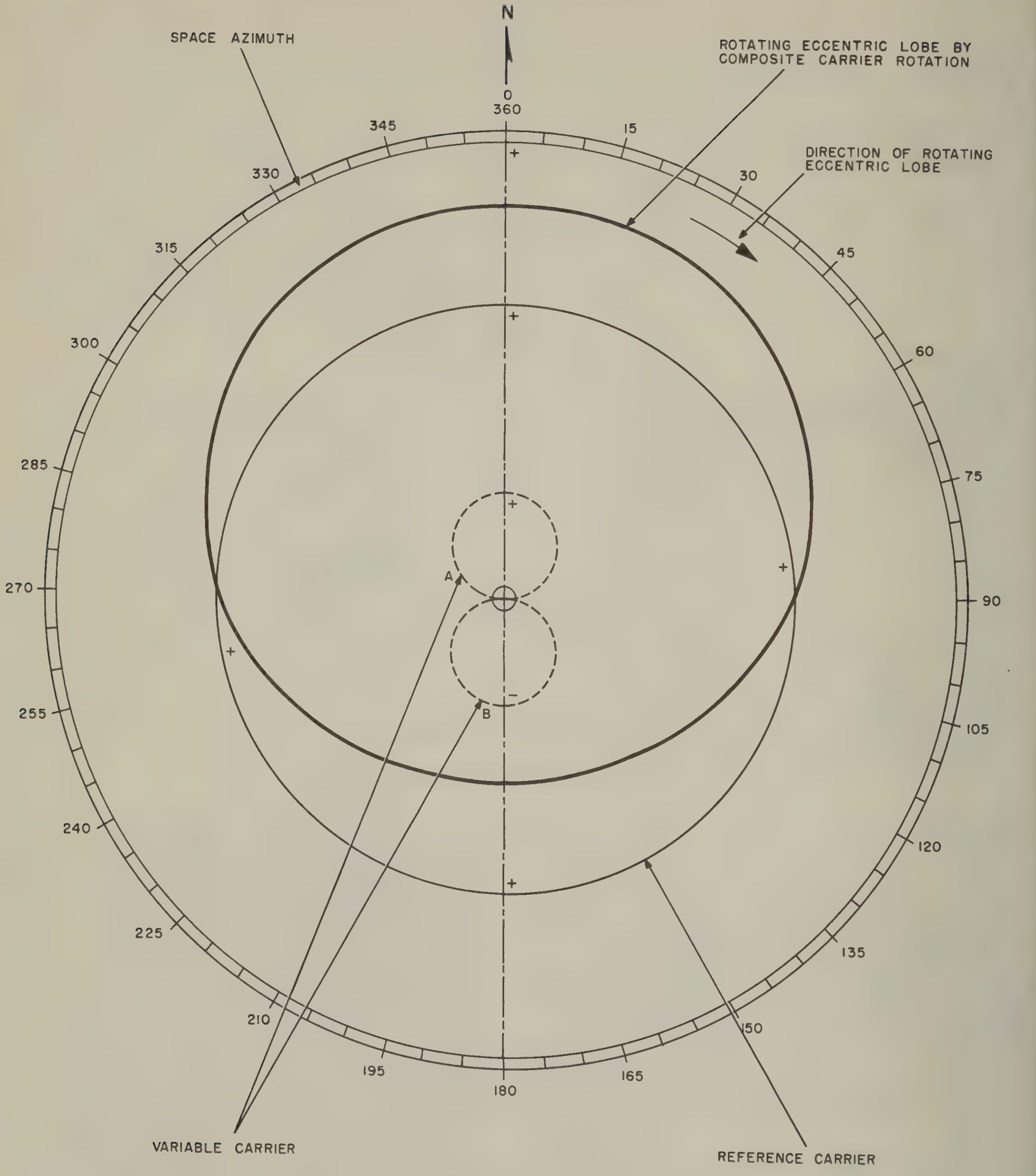


Figure 87. Rotation of figure-of-eight pattern.



TM215-122

Figure 88. Antenna AT–669/FRN–22, total radiation pattern.

is rotated through 180° and, subsequently, through 360°.

e. The application of reference carrier and variable carrier excitation to the antenna simultaneously does not affect the reference carrier radiation pattern but does alter the resultant variable carrier figure-of-eight pattern. This change is necessary to give specific identity to the eccentric rotating variable carrier radiation pattern. The eccentric variable carrier pattern (fig. 88) has been stopped at the in-phase and magnetic North position for discussion purposes. The resultant figure-of-eight, figure 86 is shown in broken lines and the lobes designated A and B. At this time, the reference carrier field is positive. With the field of variable carrier lobe A also positive, lobe A and the reference carrier are additive, and the resultant lobe is enlarged. Simultaneously, variable carrier lobe B is negative, and being superimposed on the positive reference carrier field, is partially canceled. This vector addition between reference carrier and variable carrier fields produces the final eccentric variable carrier radiation pattern. Because variable carrier lobe A is always in phase with the reference carrier radiation field, the variable carrier eccentric lobe will rotate 360° in the same configuration. The rotating eccentric variable carrier lobe, combined with the reference carrier, produces the space-modulated, phase-sensitive signal required in omnirange navigation.

f. Space modulation is a form of amplitude modulation which requires two carriers on the same frequency to be in phase. One carrier remains fixed in amplitude while the other must vary to add to, or subtract from, the fixed carrier. The modulation therefore takes place in space, and the two signals received by the receiver combine and vary in amplitude. Space modulation is similar to some types of fading and flutter in receivers when receiving both a groundwave and a reflected skywave. In the omnirange signal, the two carriers remain at constant amplitudes. Because of the rotation of the eccentric variable carrier lobe, the receiving antenna will receive varying amounts of signal, depending on the position of the variable carrier lobe maximum or minimum. The ratio between the power in the reference carrier radiation field and the variable carrier field determines the percentage of modulation at the receiver. If the radiation field of lobe A (fig. 88) were equal to the reference carrier in amplitude, 100 percent modulation would result. The amount of variable carrier power delivered to the antenna in omnirange systems is adjusted to produce 30 percent modulation. The variable carrier is rotated at a 30-cps rate by the variable carrier outputs from the goniometer.

g. To interpret the signals radiated by the antenna, a double-detection (FM and AM) VHF receiver is used. The reference carrier is amplitude-modulated by a 9,960-cps subcarrier which, in turn, is frequency-modulated at 30 cps. The receiver extracts from the reference carrier this 30-cps signal and compares the phase with that of the 30-cps modulation produced by the rotating variable carrier. The goniometer synchronizes the two transmitted 30-cps modulations at magnetic North. Thus, if the receiving antenna is located directly north of the omnirange antenna, both received 30-cps signals will be in phase. If the receiving antenna is directly east of the antenna, the variable carrier 30-cps signal will lag behind the reference 30-cps signal by 90°. The receiver accurately measures the phase difference between the reference 30-cps signal and the variable 30-cps signal with relation to magnetic North.

102. Antenna Heaters

(fig. 89)

Four heater elements are mounted between the slots on the interior of the antenna, to prevent the accumulation of moisture and fungus on the antenna interior and the formation of ice on the exterior. The four heaters are connected in series-parallel and operate on 115 volts ac supplied through circuit breaker K1002 on the antenna pedestal. Total power dissipation of the heaters is 225 watts. The heaters are shielded and connected to the antenna wall to prevent RF energy feedback into the powerline.

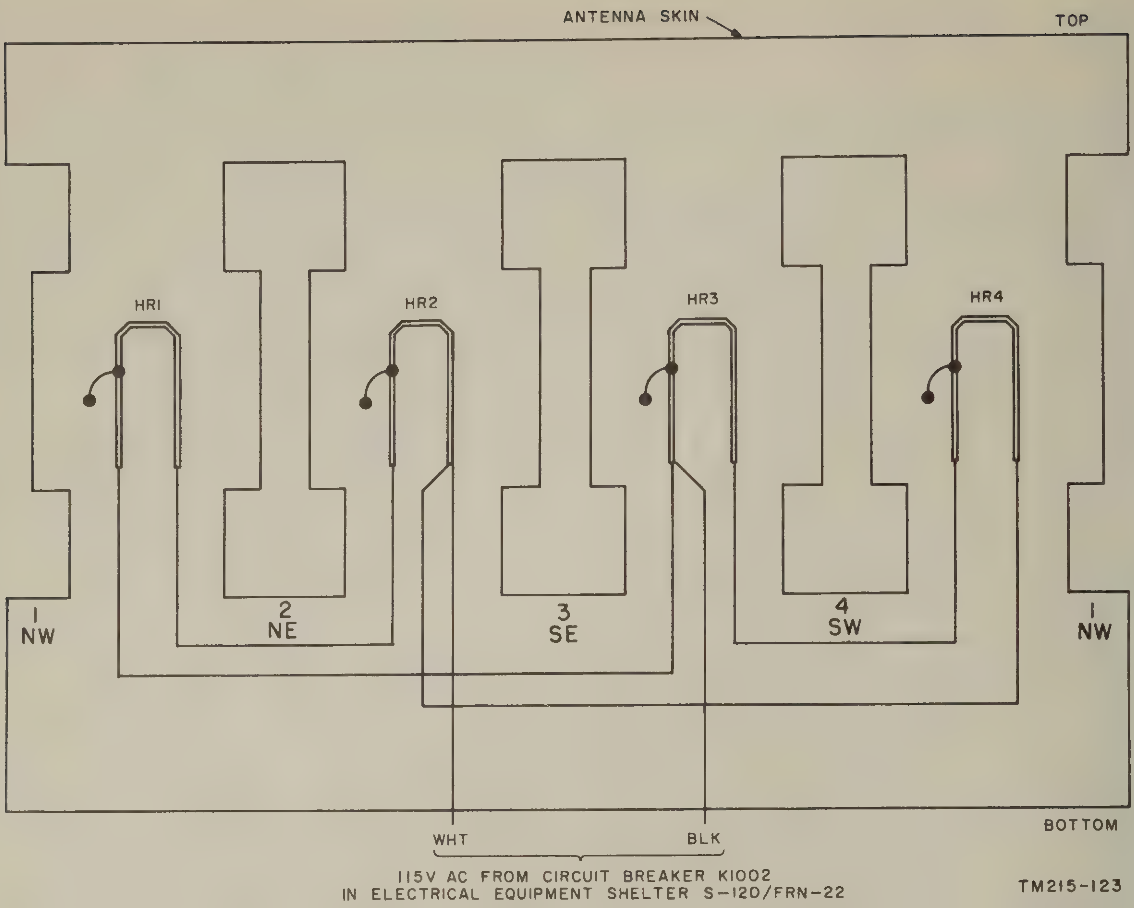

ANTENNA SKIN
TOP
HR1
HR2
HR3
HR4
1
NW
2
NE
3
SE
4
SW
1
NW
BOTTOM
WHT
BLK
115V AC FROM CIRCUIT BREAKER K1002
IN ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
TM215-123

Figure 89. Antenna AT–669/FRN–22 heaters, schematic diagram.

Section VII. THEORY OF AUDIO FREQUENCY OSCILLATOR O–371/FRN–20

103. Block Diagram

(fig. 90)

The O–371/FRN–20 produces a frequency-regulated power signal which is amplified to 115 volts by AM–1246/FRN–20 and then supplied to the motor of the goniometer. If the frequency of the main ac power is 60 cps, the O–371/FRN–20 is adjusted for an output frequency of 50 cps. If the frequency of the main ac power is 50 cps, the O–371/FRN–20 is adjusted for an output frequency of 60 cps. The 10-cycle separation prevents beat frequencies between the oscillator frequency and the main ac power frequency when the output of the O–371/FRN–20 is fed to the AM–1246/FRN–20. Beat frequencies result in slight variations in output voltage, which would cause the goniometer motor to operate erratically. The signal path is shown in the block diagram and is discussed in *a* through *h* below. For complete circuit details, refer to the overall schematic diagram (fig. 279, contained in separate envelope).

a. Oscillator amplifier V901 develops either a 50- or 60-cycle signal. This signal is amplified and fed to oscillator cathode follower V902B.

b. Oscillator-cathode follower V902B provides a low impedance feedback through a phase-shift network to the oscillator section of V901. Tube V902B also feeds a small portion of the signal to oscillator detector V902A. The output of V902B is coupled to controlled amplifier V903.

c. Oscillator detector V902A receives a small portion of the signal from V902B, detects and filters it, and furnishes a negative dc bias to V901.

d. Controlled amplifier V903 amplifies the signal received from V902B and couples it to the AM–1246/FRN–20.

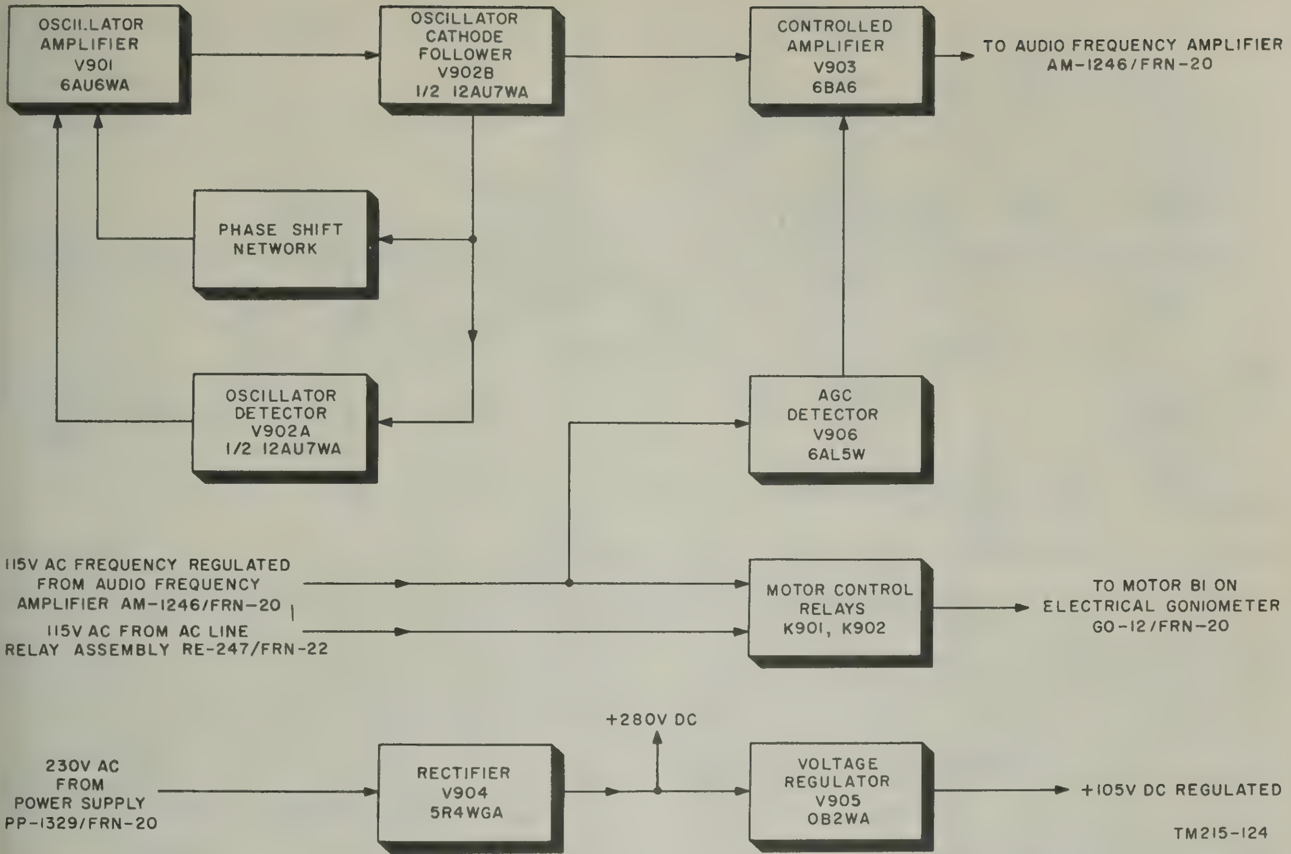

OSCILLATOR AMPLIFIER V901 6AU6WA
OSCILLATOR CATHODE FOLLOWER V902B 1/2 12AU7WA
CONTROLLED AMPLIFIER V903 6BA6
TO AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
PHASE SHIFT NETWORK
OSCILLATOR DETECTOR V902A 1/2 12AU7WA
AGC DETECTOR V906 6AL5W
115V AC FREQUENCY REGULATED FROM AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
115V AC FROM AC LINE RELAY ASSEMBLY RE-247/FRN-22
MOTOR CONTROL RELAYS K901, K902
TO MOTOR B1 ON ELECTRICAL GONIOMETER GO-12/FRN-20
+280V DC
230V AC FROM POWER SUPPLY PP-1329/FRN-20
RECTIFIER V904 5R4WGA
VOLTAGE REGULATOR V905 OB2WA
+105V DC REGULATED
TM215-124

Figure 90. Audio Frequency Oscillator O-371/FRN-20, block diagram.

e. Agc detector V906 rectifies a portion of the 115-volt frequency-regulated signal. The rectified signal is then filtered to obtain a negative bias which is applied to V903.

f. Dc operating voltages for the O-371/FRN-20 are supplied by rectifier V904.

g. Tube V905 furnishes a regulated voltage to control the operating point of tube V906 and furnishes operating voltages for V901 and V902.

h. Motor control relays K901 and K902 permit the goniometer motor to start on power supplied by the 115-volt ac line and, after a time delay, switch the motor to the frequency-regulated 115-volt output of the AM-1246/FRN-20.

104. Oscillator Amplifier V901 and Oscillator Cathode Follower V902B

(fig. 91)

Oscillator amplifier V901 uses a 6AU6WA pentode as one section of a two-section, phase-shift oscillator. Oscillator cathode follower V902B uses one-half of a 12AU7WA twin triode as the other section of the oscillator to provide a low impedance feedback circuit.

a. Tube V901 develops a stable 50- or 60-cycle signal which is amplified and coupled to the grid of V902B through capacitor C906. The output of V901 is maintained at a constant level by an agc bias voltage from oscillator detector V902A. Self-bias is developed across cathode resistor R906, which adds to the agc bias applied through grid resistor R904.

b. Plate voltage is obtained from voltage regulator V905 through plate load resistor R908. Screen voltage is obtained from voltage regulator V905 through screen dropping resistor R907. The screen is bypassed to ground by capacitor C905.

c. Tube V902B receives the signal from V901 through coupling capacitor C906 and develops three low impedance outputs in its cathode circuit.

d. The oscillator output signal developed across cathode resistor R912 is coupled through capacitor C907 to the grid of controlled amplifier V903. An output signal developed across cathode resistors R910, R911, and R912 is fed back to the grid of V901 through a three-section,

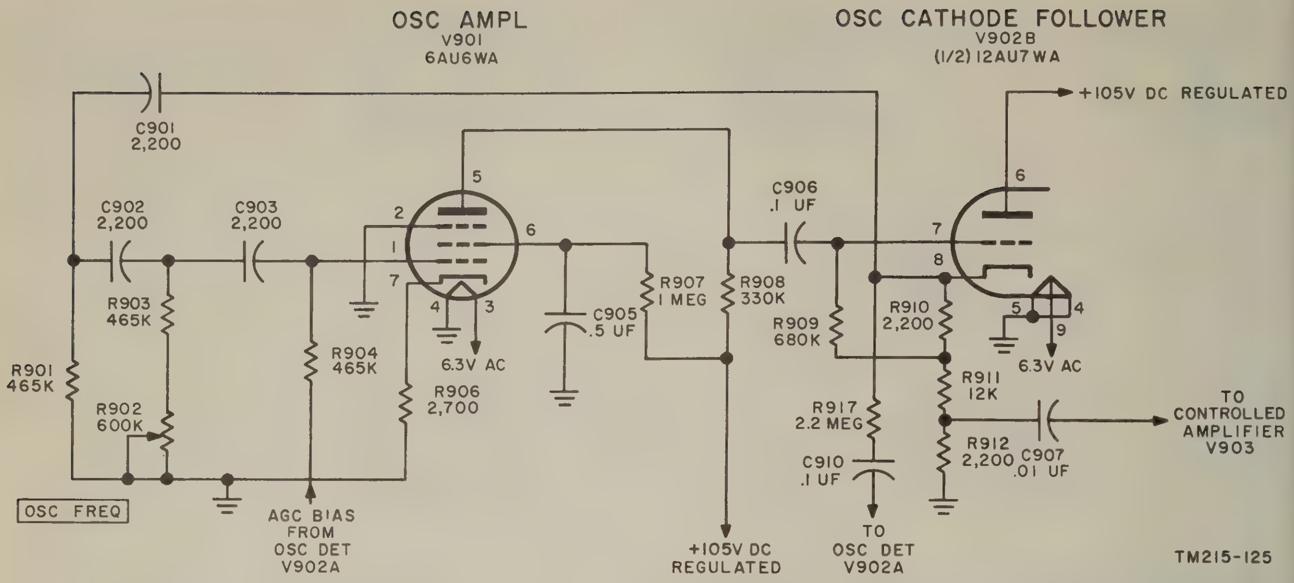


Figure 91. Oscillator amplifier V901 and oscillator cathode follower V902B, schematic diagram.

phase-shift network. One section consists of capacitor C901 and resistor R901. Another section consists of capacitor C902, resistor R903, and OSC FREQ control R902. A third section consists of capacitor C903 and resistor R904. A phase shift of 60° is obtained in each section, making a total phase shift of 180° through the network. The amount of phase shift in each section increases as the frequency decreases or decreases as the frequency increases, providing frequency regulation of the oscillator. This 180° phase shift added to the 180° phase shift of tube V901 produces the 360° phase shift required for oscillations.

e. OSC FREQ control R902 is used to adjust the frequency of the oscillator to either 50 or 60 cps. As the resistance of OSC FREQ control R902 is increased, it reduces the phase shift of section two of the three-section, phase-shift network. This causes the oscillator frequency to decrease so as to increase the total phase shift of the network back to 180°.

f. A small portion of the oscillator signal is coupled from the cathode of V902B through series resistor R917 and coupling capacitor C910 to oscillator detector V902A.

g. Self-bias for V902B is developed across cathode resistors R910, R911, and R912. Grid load resistor R909 connects to the cathode circuit at the junction of resistors R910 and R911. Plate voltage for V902B is obtained directly from voltage regulator V905.

105. Oscillator Detector V902A

(fig. 92)

Oscillator detector V902A uses one-half of a 12AU7WA dual triode connected as a diode to produce an agc voltage that controls the output of oscillator amplifier V901. A small portion of the signal developed in the cathode circuit of

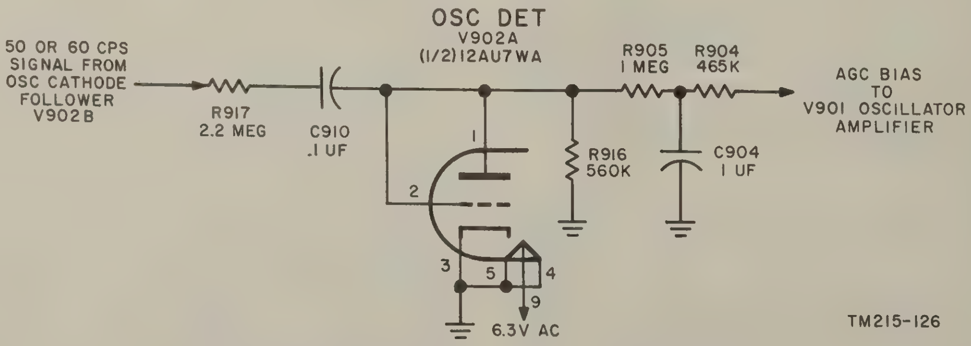


Figure 92. Oscillator detector V902A, schematic diagram.

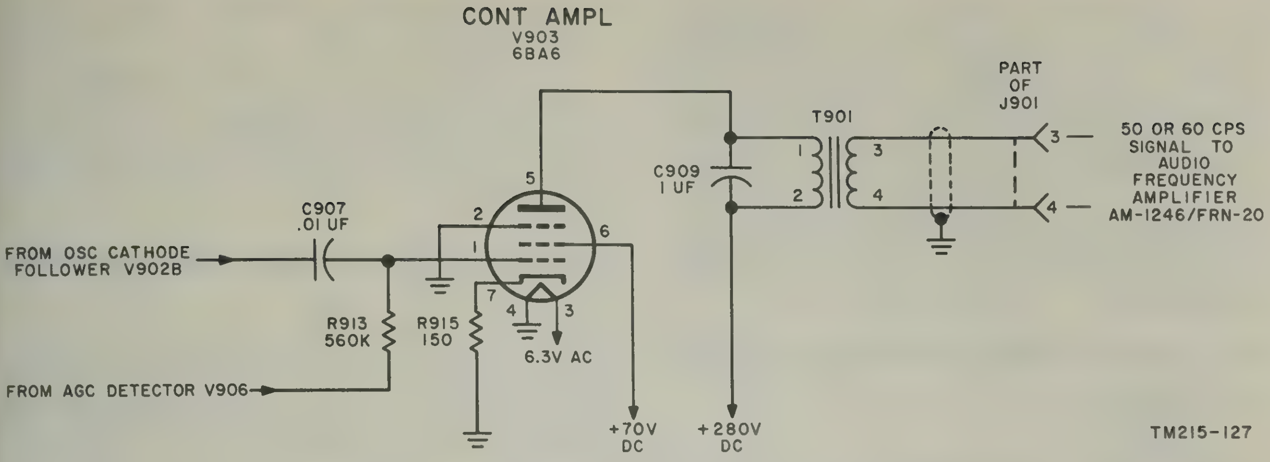


Figure 93. Controlled amplifier V903, schematic diagram.

V902B is coupled to the plate of V902A through resistor R917 and capacitor C910. The output voltage drop across load resistor R916 is filtered by resistor R905 and capacitor C904 to produce a negative voltage. This bias voltage is applied through resistor R904 to the grid of oscillator amplifier V901.

106. Controlled Amplifier V903

(fig. 93)

Controlled amplifier V903 uses a 6BA6 pentode to amplify the signal received from V902B. The output of V903 is fed through receptacle J901 to AM-1246/FRN-20.

a. The output signal of V902B is coupled through capacitor C907 to the grid of V903. The output signal of V903 is developed in transformer T901. Capacitor C909, shunted across the primary of transformer T901, reduces harmonics and eliminates any spurious oscillations. Plate voltage is obtained from bleeder resistor R924. Screen voltage is obtained from bleeder resistor R923.

b. Self-bias is developed across cathode resistor R915, which adds to the agc bias connected through grid resistor R913 from agc detector V906.

107. Agc Detector V906

(fig. 94)

Agc detector V906 uses a 6AL5W dual diode to develop an agc voltage that controls the output of V903.

a. REGULATOR control R920, in series with resistor R921, furnishes a positive dc voltage to the cathodes of V906 through transformer T1403 on PP-1329/FRN-20. This voltage presets the desired level of regulation. The frequency-regulated 115 volts ac from transformer T1403 is fed to the two cathodes of V906 through receptacle J902.

b. The output of V906 is developed across

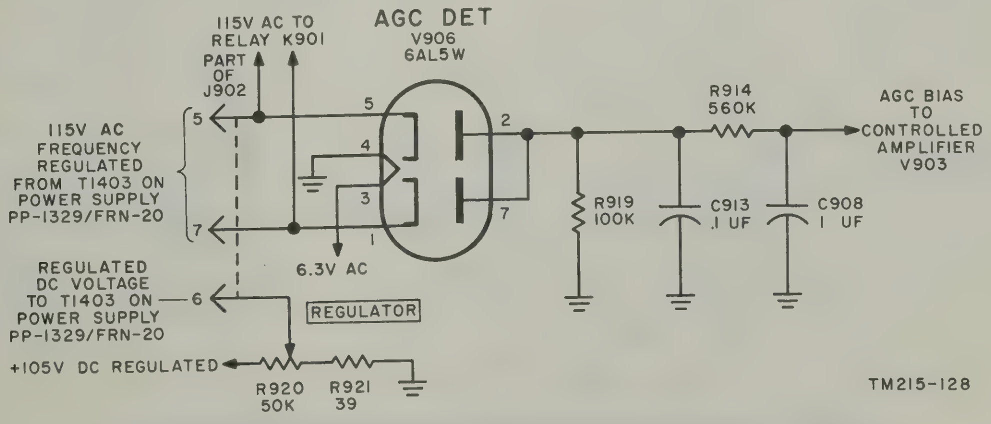

115V AC TO RELAY K901
AGC DET
V906
6AL5W
PART OF J902
115V AC FREQUENCY REGULATED FROM T1403 ON POWER SUPPLY PP-1329/FRN-20
REGULATED DC VOLTAGE TO T1403 ON POWER SUPPLY PP-1329/FRN-20
6.3V AC
REGULATOR
+105V DC REGULATED
R920 50K
R921 39
R914 560K
R919 100K
C913 .1 UF
C908 1 UF
AGC BIAS TO CONTROLLED AMPLIFIER V903
TM215-128

Figure 94. Agc detector V906, schematic diagram.

plate load resistor R919 and is filtered by resistor R914 and capacitors C913 and C908 to produce a negative voltage. This negative bias is applied to the grid of V903. As the amplitude of the frequency-regulated voltage applied to the cathodes of V906 increases in a negative direction to a potential greater than the dc voltage applied to the cathodes, the diode current increases and causes an increase in the negative bias applied to V903.

108. Rectifier V904 and Voltage Regulator V905

(fig. 95)

Rectifier V904 uses a 5R4WGA full-wave rectifier to supply operating voltages for the plate and screen of V903 and to feed voltage regulator V905. Voltage regulator V905 uses an OB2WA regulator tube to provide +105 volts dc for the plate and screen of V901, the plate of V902B and the voltage applied to the cathodes of V906, through the PP–1329/FRN–20.

a. The 230 volts ac from receptacle J902 is applied to transformer T902 through fuses F901 and F902. A center-tapped, high-voltage secondary winding on T902 furnishes 350 volts ac to the plates of rectifier V904.

b. The output of V904 is filtered by chokes L901 and L902 and capacitors C911 and C912. Bleeder resistors R923 and R924 provide two different potentials of operating voltage in addition to a discharge path for capacitors C911 and C912 when the O–371/FRN–20 is turned off. The output of the choke input filter is connected through series resistor R918 to the plate of voltage regulator V905.

c. Filament voltage for V904 is supplied by a 5-volt secondary winding on T902. Filament voltage for V901, V902, V903, and V906 is supplied by a 6.3-volt secondary winding on transformer T902.

109. Motor Control Relays K901 and K902

(fig. 96)

Motor control relay K901 switches the goniometer motor from the line voltage to the frequency-regulated voltage through J902 after it is energized by voltage from thermal relay K902. Relay K901 (through J901) also closes the cathode circuit of power amplifier tubes V4 and V5 in the AM–1246/FRN–20.

a. The 115-volt ac line voltage from the RE–247/FRN–22 is applied through receptacle J902 to the heater element of relay K902 and through the deenergized contacts of relay K901 and receptacle J902 to the goniometer motor. The goniometer motor will run approximately 60 seconds on the line voltage while thermal relay K902 is heating. After the contacts close on relay K902, 115 volts ac is applied to the coil of relay K901. This voltage energizes K901, which removes the line voltage from the goniometer motor and applies the frequency-regulated 115-volt output of the AM–1246/FRN–20 through J902. The contacts of thermal relay K902 are shunted by capacitor C914 to reduce arcing.

b. Additional contacts on relay K901 close the cathode return of power amplifier tubes V4 and

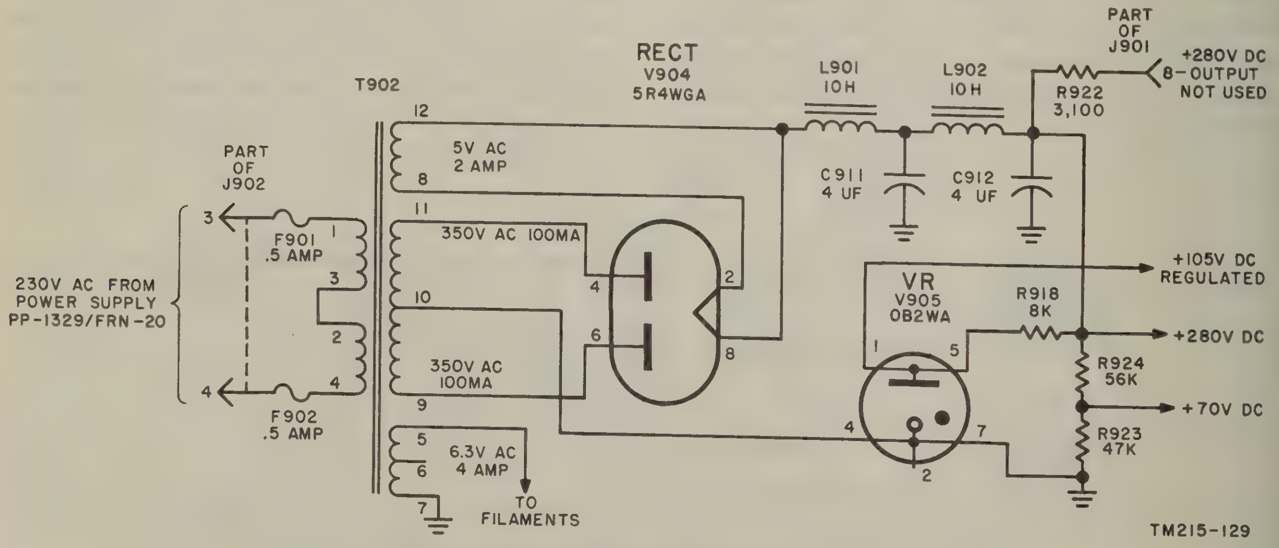


Figure 95. Rectifier V904 and voltage regulator V905, schematic diagram.

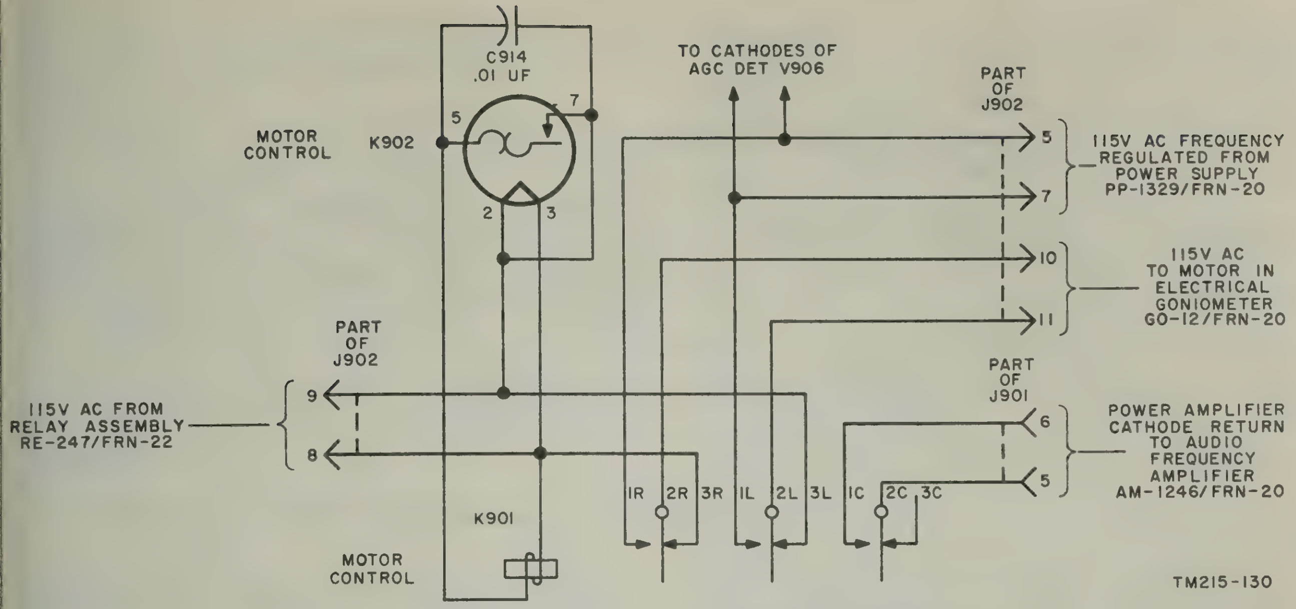


Figure 96. Motor control relays K901 and K902, schematic diagram.

V5 in the AM–1246/FRN–20 through J901. This is a safety measure to prevent the tubes from conducting in case relay K901 or K902 fail to operate.

Section VIII. THEORY OF AUDIO FREQUENCY AMPLIFIER AM–1246/FRN–20

110. Block Diagram

(fig. 97)

The AM–1246/FRN–20 receives the frequency-regulated power signal produced by the O–371/FRN–20 and amplifies it to 115 volts so it can operate the goniometer motor. The signal path is shown in the block diagram and is discussed in *a* through *d* below. For complete circuit details, refer to the overall schematic diagram (fig. 280).

a. The frequency-regulated power signal from the O–371/FRN–20 is coupled to first amplifier V1 where it is amplified, then coupled to driver amplifier V2 and V3.

b. Driver amplifier V2 and V3 increases the signal to obtain sufficient power to drive power amplifier V4 and V5.

c. Power amplifier V4 and V5 further increases the signal to produce frequency-regulated 115 volts ac in the secondary of output transformer T1403, which is located in the PP–1329/FRN–20.

d. Operating voltages for the frequency-regulating amplifier are supplied by the PP–1329/FRN–20.

111. First Amplifier V1

(fig. 98)

First amplifier V1 uses a 6SN7WGTA twin triode to amplify the 50- or 60-cps signal from the O–371/FRN–20. The output of V1 is transformer-coupled to driver amplifier V2 and V3.

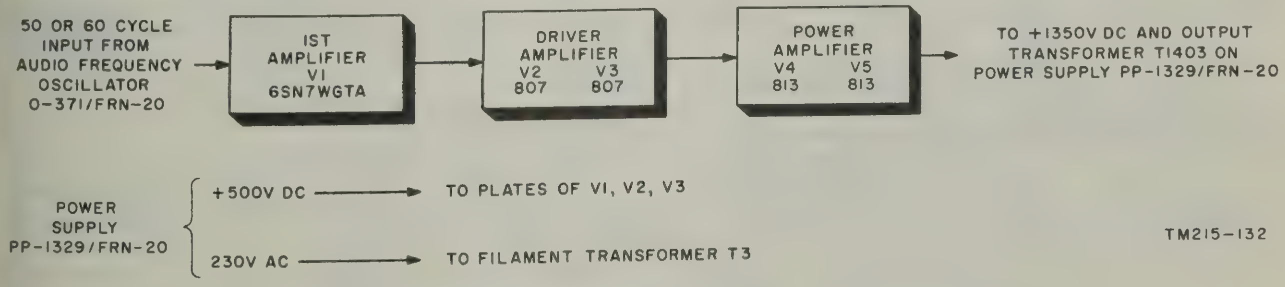


Figure 97. Audio Frequency Amplifier AM–1246/FRN–20, block diagram.

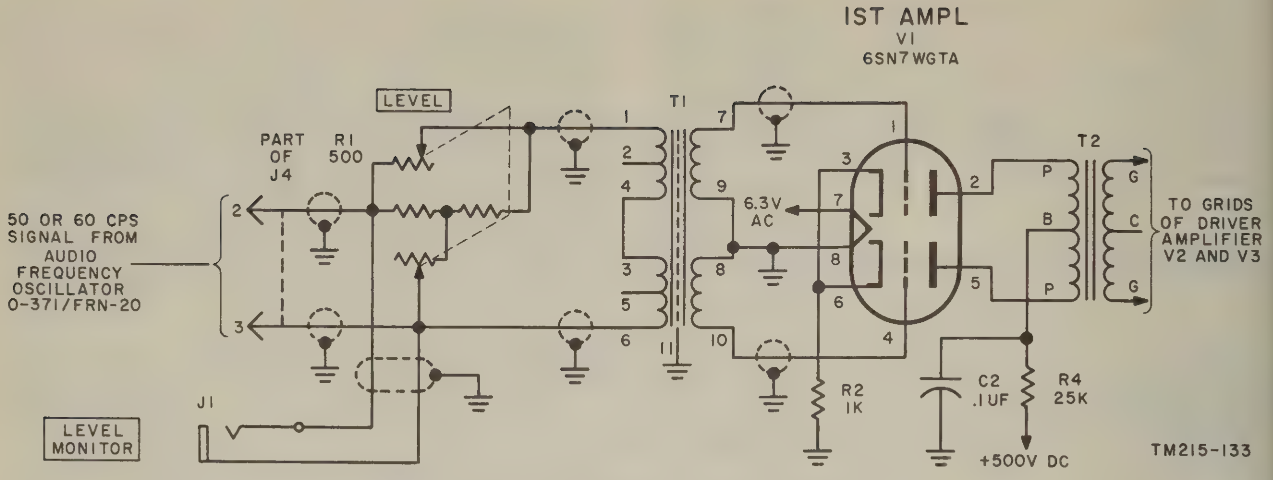

IST AMPL
V1
6SN7WGTA
LEVEL
PART OF J4
R1 500
T1
T2
50 OR 60 CPS SIGNAL FROM AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
6.3V AC
TO GRIDS OF DRIVER AMPLIFIER V2 AND V3
J1
LEVEL MONITOR
R2 1K
C2 .1UF
R4 25K
+500V DC
TM215-133

Figure 98. First amplifier V1, schematic diagram.

a. The input signal is fed through receptacle J4 to LEVEL control R1 where it is attenuated to the desired level and applied to the primary of input transformer T1. LEVEL MONITOR receptacle J1 is connected across the input for monitoring the input signal.

b. Tube V1, connected as a push-pull amplifier, receives the signal from the center-tapped secondary winding of transformer T1. The signal is amplified by V1 and transformer-coupled to driver-amplifier V2 and V3 through transformer T2.

c. Plate voltage is obtained from the PP–1329/FRN–20 through receptacle J3 and dropping resistor R4. Signal voltages in the plate circuit are bypassed to ground by capacitor C2. Self-bias is developed by the voltage drop across cathode resistor R2.

d. Filament voltage is supplied by a 6.3-volt secondary winding on transformer T4. The primary of T4 is operated on 230 volts ac from the PP–1329/FRN–20 through receptacle J4.

112. Driver Amplifier V2 and V3

(fig. 99)

Driver amplifier V2 and V3 uses two 807 beam power tubes to amplify the signal received from V1 and to furnish grid driving power for power amplifier V4 and V5.

a. This stage operates as a push-pull class A amplifier, and receives the signal from V1 through interstage transformer T2. The output

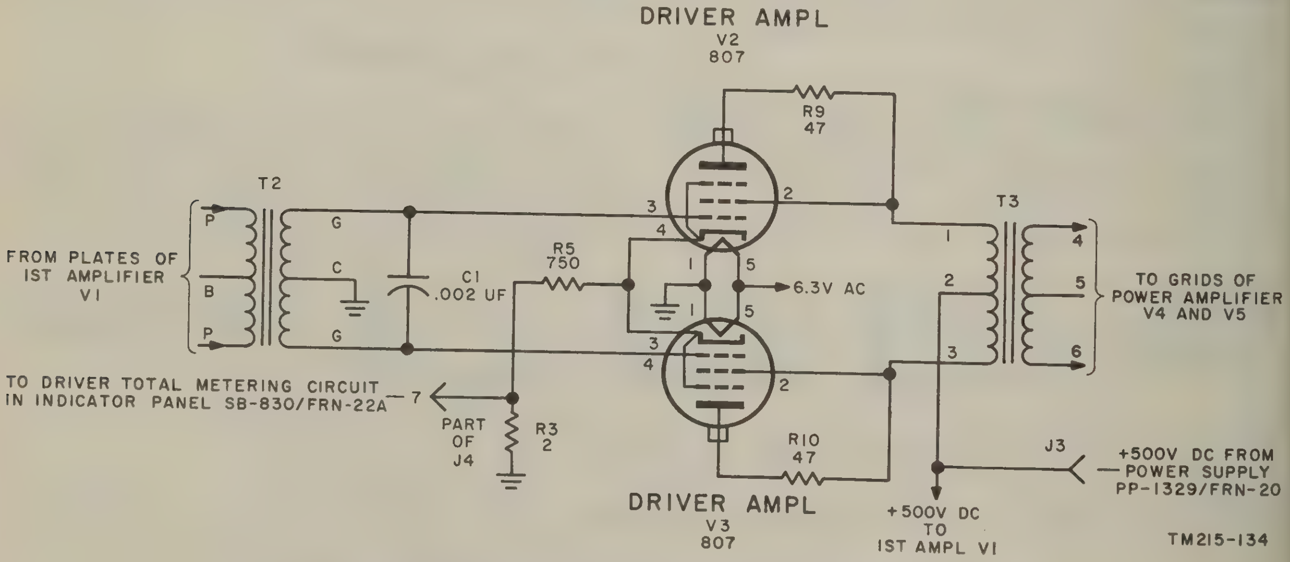

DRIVER AMPL
V2
807
R9 47
T2
T3
FROM PLATES OF IST AMPLIFIER V1
C1 .002 UF
R5 750
6.3V AC
TO GRIDS OF POWER AMPLIFIER V4 AND V5
TO DRIVER TOTAL METERING CIRCUIT IN INDICATOR PANEL SB-830/FRN-22A
PART OF J4
R3 2
R10 47
DRIVER AMPL
V3
807
+500V DC TO IST AMPL V1
J3
+500V DC FROM POWER SUPPLY PP-1329/FRN-20
TM215-134

Figure 99. Driver amplifier V2 and V3, schematic diagram.

signal of V2 and V3 is developed in driver transformer T3 and coupled to the grids of power amplifier V4 and V5.

b. Plate and screen voltage is obtained from the PP–1329/FRN–20 through receptacle J3. Resistors R9 and R10 are parasitic suppressors. Self-bias is developed by cathode resistor R5. Damping capacitor C1 is connected across the secondary of transformer T2. Filament voltage is supplied by a 6.3-volt secondary winding on transformer T4.

c. The total cathode current is metered through meter shunt resistor R3 by meter M1901 on the meter panel.

113. Power Amplifier V4 and V5

(fig. 100)

Power amplifier V4 and V5 uses two 813 beam power tubes to amplify the signal from V2 and V3 and furnish frequency-regulated 115 volts ac to operate the goniometer motor.

a. This stage operates as a push-pull, class B amplifier, and receives the signal through driver transformer T3. The output power is developed in transformer T1403 on the PP–1329/FRN–20 (fig. 281). The secondary of T1403 connects through motor control relay K901 in the O–371/FRN–20 to the goniometer motor. Plate voltage for V4 and V5 is obtained from the PP–1329/FRN–20 through output transformer T1403.

b. A high bias value is developed across cathode resistor R6 in series with OVERLOAD CONTROL R7 and metering resistor R8 when the transmitting equipment is placed in a warmup condition. This reduces tube currents to negligible values. Approximately 60 seconds after the transmitting equipment is placed on the air as a navigational facility, resistor R6 is shorted by contacts on relay K901 in the O–371/FRN–20 to reduce the bias to near zero. To protect V4 and V5, the coil of overload relay S2 is shunted across OVERLOAD CONTROL R7 in the cathode circuit. OVERLOAD CONTROL R7 is adjusted to preset the amount of cathode current that flows through the coil of overload relay S2. When the current through the coil of relay S2 increases above this value, relay S2 will energize and open

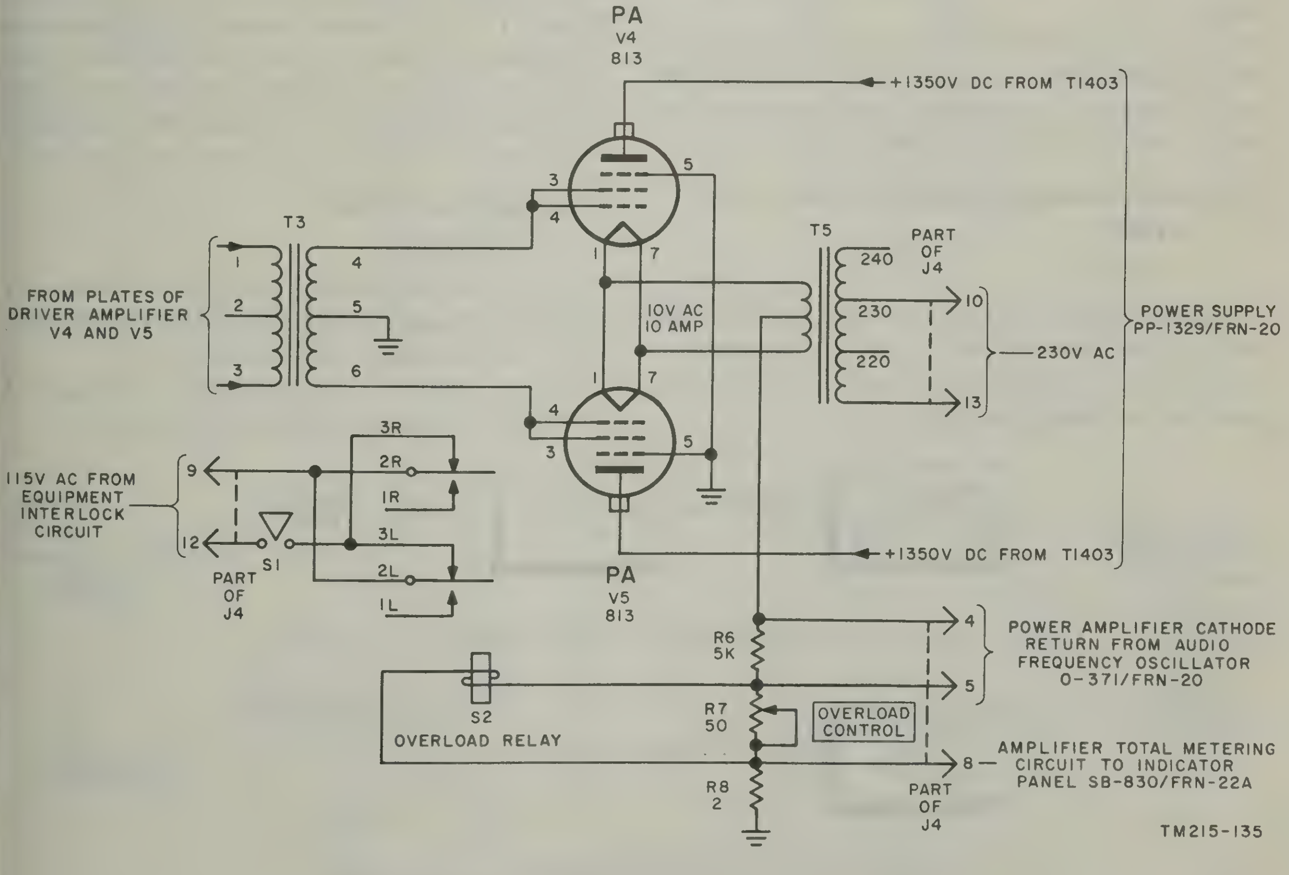

PA
V4
813
+1350V DC FROM T1403
T3
1
2
3
4
5
6
FROM PLATES OF DRIVER AMPLIFIER V4 AND V5
3
4
5
1
7
10V AC 10 AMP
T5
240
230
220
PART OF J4
10
13
230V AC
POWER SUPPLY PP-1329/FRN-20
4
3
5
1
7
3R
2R
1R
3L
2L
1L
9
12
115V AC FROM EQUIPMENT INTERLOCK CIRCUIT
S1
PART OF J4
PA
V5
813
+1350V DC FROM T1403
R6
5K
R7
50
R8
2
OVERLOAD CONTROL
S2
OVERLOAD RELAY
4
5
8
POWER AMPLIFIER CATHODE RETURN FROM AUDIO FREQUENCY OSCILLATOR O-371/FRN-20
AMPLIFIER TOTAL METERING CIRCUIT TO INDICATOR PANEL SB-830/FRN-22A
PART OF J4
TM215-135

Figure 100. Power amplifier V4 and V5, schematic diagram.

the equipment interlock circuit. Panel interlock switch S1 is connected in series with the equipment interlock circuit. Total current of V4 and V5 is metered through meter shunt by meter M1901 on the meter panel.

c. Filament voltage for V4 and V5 is supplied by the 10-volt secondary winding on transformer T5. The primary of T5 is operated on 230 volts ac from the PP–1329/FRN–20 through receptacle J4.

Section IX. THEORY OF POWER SUPPLY PP–1329/FRN–20

114. Block Diagram

(fig. 101)

Power Supply PP–1329/FRN–20 supplies the operating voltages for the O–371/FRN–20 and AM–1246/FRN–20. The O–371/FRN–20 contains two rectifier circuits with associated control relays and the AM–1246/FRN–20 output transformer. For complete circuit details, refer to the overall schematic diagram (fig. 281).

a. Full-wave, high-voltage rectifier V1401 and V1402 provides +1,350 volts dc for the AM–1246/FRN–20.

b. Full-wave rectifier V1403 provides +500 volts dc for the AM–1246/FRN–20.

c. Output transformer T1403 couples the AM–1246/FRN–20 output to the motor on the goniometer.

d. Ac power of 230 volts is fed through the PP–1329/FRN–20 to operate the O–371/FRN–20 and to supply a transformer that furnishes filament voltage for the AM–1246/FRN–20.

115. High-Voltage Rectifier V1401 and V1402

(fig. 102)

A high-voltage rectifier circuit is used to develop +1,350 volts dc for V4 and V5 in the AM–1246/FRN–20. Tubes V1401 and V1402, 3B28 gas-filled rectifiers, are used.

a. Ac power of 230 volts is applied through the contacts of main relay K1401 and plate relay K1402 to the primary of transformer T1402. A center-tapped secondary winding of transformer T1402 furnishes 1,500 volts ac to the plates of V1401 and V1402. Transformer T1402 is protected by fuses F1408 and F1409.

b. Filaments of the two 3B28 rectifiers are connected in parallel and receive their power from a 2.5-volt secondary winding on transformer T1401.

c. The output of the high-voltage rectifier is fed from the center tap of the 2.5-volt winding to a two-section choke input filter consisting of chokes L1403 and L1404 and capacitors C1403 and C1404. The output of the filter supplies +1,350 volts dc to the center tap of output transformer T1403. Bleeder resistor R1402 provides the necessary bleeder current for regulation and a discharge path for capacitors C1403 and C1404 after the power supply is turned off. The high-voltage rectifier circuit is protected by fuse F1411.

116. Rectifier V1403

(fig. 102)

A full-wave rectifier circuit supplies +500 volts dc for V1, V2, and V3 in the AM–1246/FRN–20. Tube V1403, a 5R4WGA, is used.

a. Two taps on the secondary winding of T1402 furnish 645 volts ac to the plates.

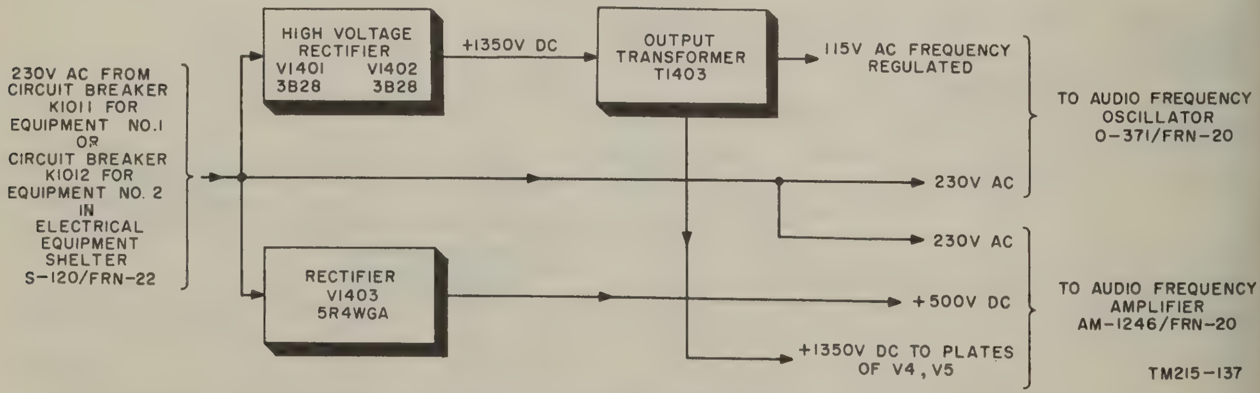

230V AC FROM CIRCUIT BREAKER K1011 FOR EQUIPMENT NO.1 OR CIRCUIT BREAKER K1012 FOR EQUIPMENT NO. 2 IN ELECTRICAL EQUIPMENT SHELTER S–120/FRN–22
HIGH VOLTAGE RECTIFIER V1401 V1402 3B28 3B28
+1350V DC
OUTPUT TRANSFORMER T1403
115V AC FREQUENCY REGULATED
TO AUDIO FREQUENCY OSCILLATOR O–371/FRN–20
230V AC
230V AC
RECTIFIER V1403 5R4WGA
+500V DC
+1350V DC TO PLATES OF V4, V5
TO AUDIO FREQUENCY AMPLIFIER AM–1246/FRN–20
TM215–137

Figure 101. Power Supply PP–1329/FRN–20, block diagram.

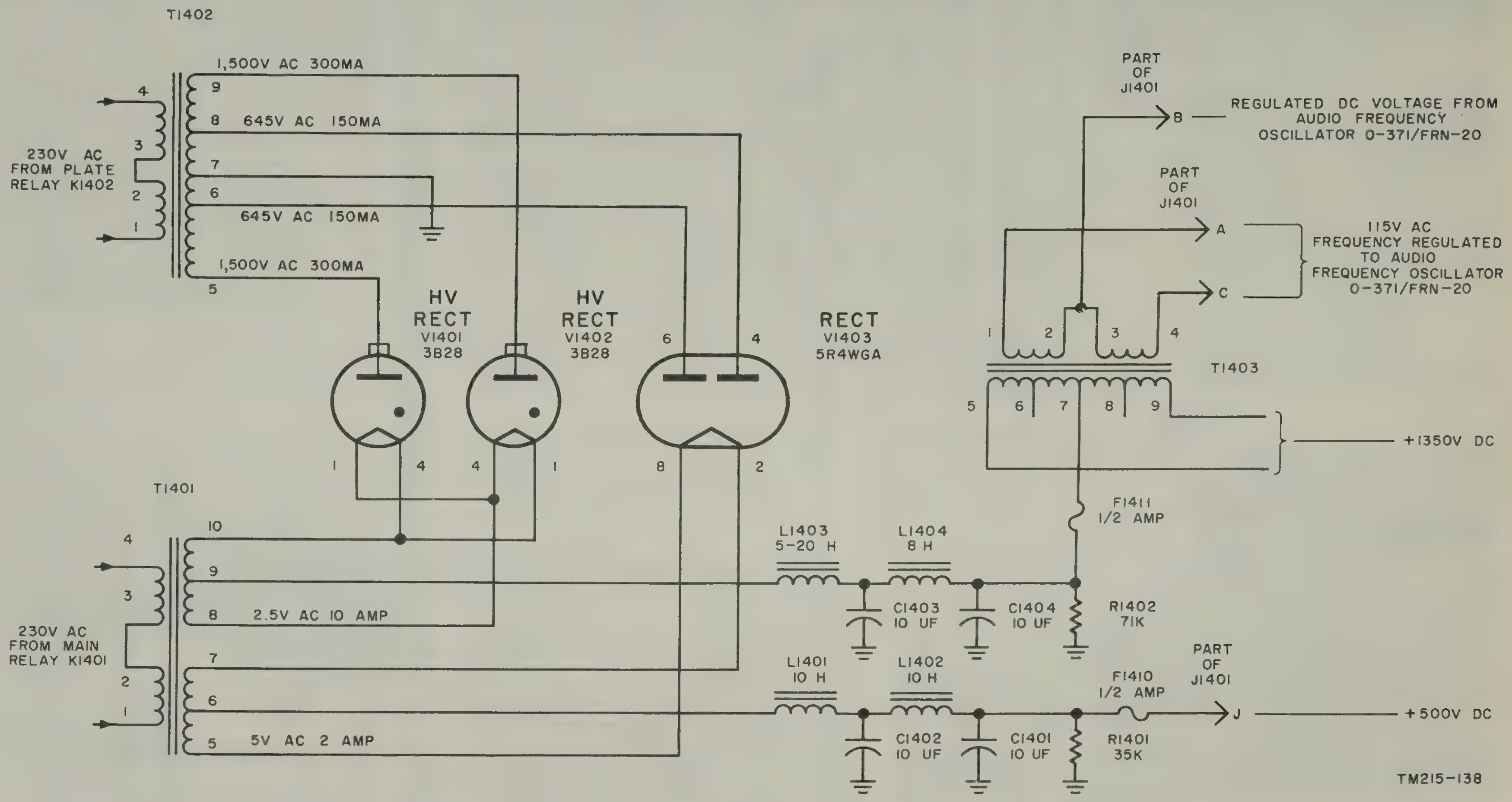


Figure 102. Rectifiers V1401, V1402, and V1403 and output transformer T1403, schematic diagram.

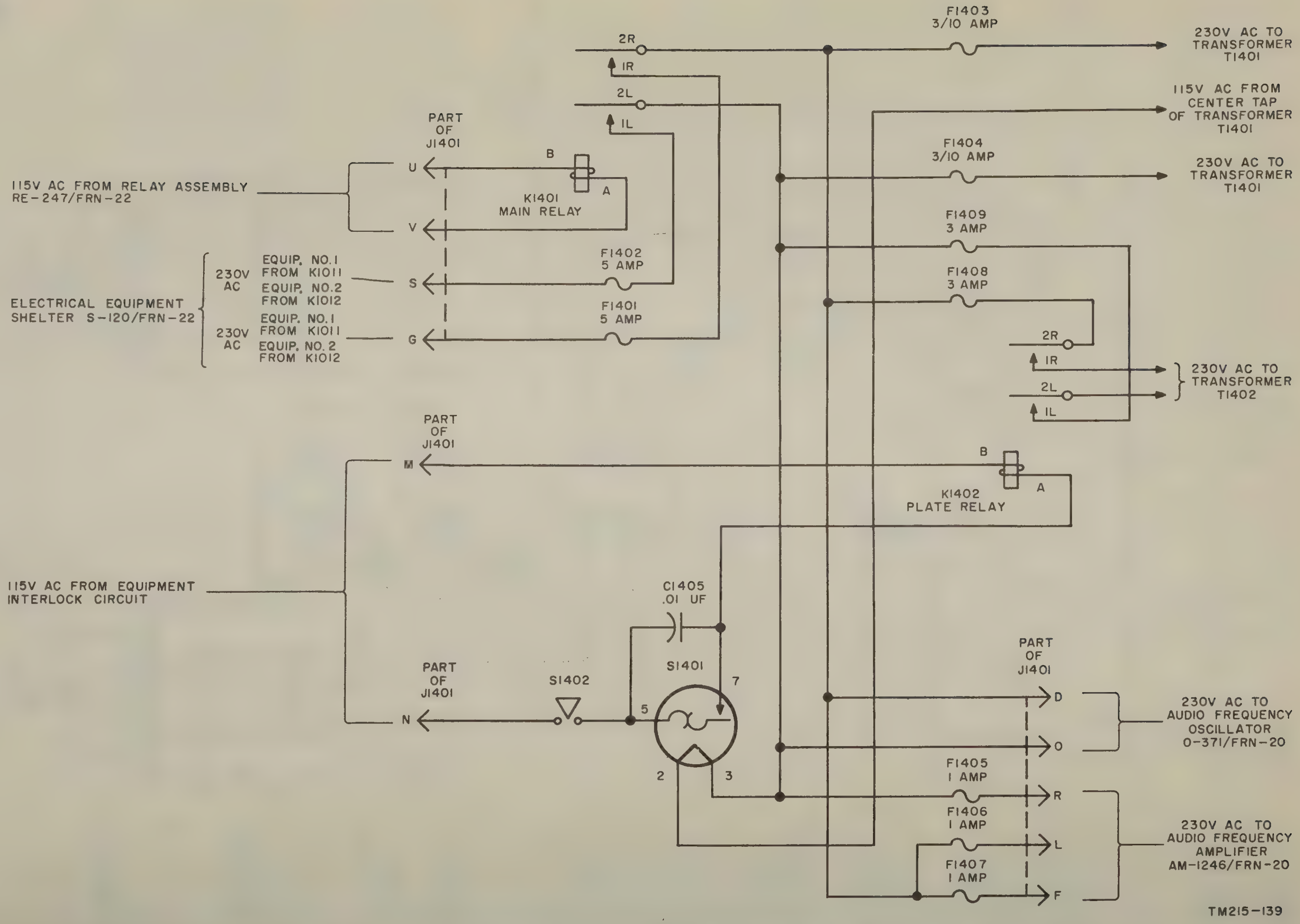

F1403
3/10 AMP
230V AC TO TRANSFORMER T1401
2R
1R
2L
1L
115V AC FROM CENTER TAP OF TRANSFORMER T1401
PART OF J1401
U
V
S
G
M
N
D
O
R
L
F
B
A
K1401
MAIN RELAY
F1404
3/10 AMP
230V AC TO TRANSFORMER T1401
115V AC FROM RELAY ASSEMBLY RE-247/FRN-22
F1409
3 AMP
F1408
3 AMP
F1402
5 AMP
F1401
5 AMP
230V AC
EQUIP. NO.1 FROM K1011
EQUIP. NO.2 FROM K1012
ELECTRICAL EQUIPMENT SHELTER S-120/FRN-22
230V AC TO TRANSFORMER T1402
K1402
PLATE RELAY
115V AC FROM EQUIPMENT INTERLOCK CIRCUIT
C1405
.01 UF
S1401
S1402
5
7
2
3
F1405
1 AMP
F1406
1 AMP
F1407
1 AMP
230V AC TO AUDIO FREQUENCY OSCILLATOR 0-371/FRN-20
230V AC TO AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
TM215-139

Figure 103. Control circuits, schematic diagram.

b. The filament receives its power from a 5-volt secondary winding on transformer T1401.

c. The output is fed from the center tap of the 5-volt winding to a two-section choke input filter consisting of chokes L1401 and L1402 and capacitors C1401 and C1402. The output of the filter supplies +500 volts dc to receptacle J1401. Bleeder resistor R1401 provides the necessary bleeder current for regulations and a discharge path for capacitors C1401 and C1402 after the power supply is turned off. Rectifier V1403 circuit is protected by fuse F1410.

117. Control Circuits

(fig. 103)

Control circuits of the PP–1329/FRN–20 delay the ac power applied to plate transformer T1402 until tube filaments are at operating temperature and open the ac line to plate transformer T1402 when the equipment interlock circuit is opened.

a. Ac power at 230 volts is applied through terminals G and S of receptacle J1401 and fuses F1401 and F1402 to the contacts of main relay K1401. Relay K1401 is energized by 115 volts ac from the RE–247/FRN–22 when the transmitting equipment is placed in a warmup condition. The 230 volts ac is then applied from the energized contacts of relay K1401 to filament transformer T1401 through fuses F1403 and F1404, to the contacts of plate relay K1402 through fuses F1408 and F1409, directly to the O–371/FRN–20 and to the AM–1246/FRN–20 through fuses F1405, F1406, and F1407.

b. The primary center tap on transformer T1401 applies 115 volts ac to the heater of thermal relay S1401. After approximately 30 seconds, the contact of S1401 close. Capacitor C1405 shunts the contacts to reduce arcing. Ac power at 115 volts from the equipment interlock circuit is applied through panel interlock switch S1402 and the contacts of thermal relay S1401 to the coil of plate relay K1402. Relay K1402, when energized, applies 230 volts ac to the primary of transformer T1402.

Section X. THEORY OF INDICATOR PANEL SB–830/FRN–22A

118. General

Meters on the meter panel indicate the frequency and voltage of the power supplied to the motor in the No. 1 or No. 2 goniometer and the cathode currents in the No. 1 or No. 2 AM–1246/FRN–20.

119. Meters and Meter Switching

(fig. 282, contained in separate envelope)

The meter circuits consist of multiscale milliammeter M1901, vibrating reed frequency meter M1902, voltmeter M1903, and rotary switches S1901 and S1902. CURRENT meter M1901, in conjunction with CURRENT switch S1901, indicates the amplifier total and driver total currents in the No. 1 or No. 2 frequency-regulating amplifier. FREQUENCY meter M1902 and VOLTS meter M1903, used in conjunction with LINE switch S1902, indicate the frequency and voltage of the ac power supplied to the motor of the No. 1 or No. 2 goniometer. Connections to the meter panel are made through terminal board TB1901.

Section XI. THEORY OF AUDIO FREQUENCY OSCILLATOR O–373/FRN

120. Block Diagram

(fig. 104)

The O–373/FRN develops a 1,000-cycle tone signal and supplies it to keyer KY–175/FRN where it is interrupted to produce the call letters of the omnirange station. The signal path is shown in the block diagram and is discussed in *a* and *b* below. For complete circuit details, refer to the overall schematic diagram (fig. 283).

a. Oscillator V1 develops the 1,000-cycle tone signal. Audio amplifier V2A and output amplifier V2B increase the 1,000-cycle signal received from the oscillator. The output of V2B is fed to the keyer.

b. Dc operating voltages for the tone oscillator are supplied by rectifier V3.

121. Oscillator V1

(fig. 105)

Oscillator V1 uses a 6SJ7WGT pentode as a transitron oscillator to develop a low level 1,000-cycle tone signal.

a. This circuit employs the negative resistance characteristic of a pentode vacuum tube to form

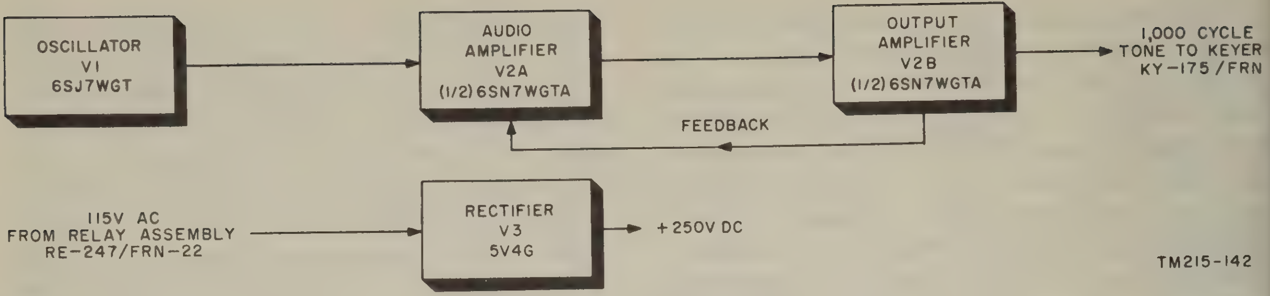


Figure 104. Audio Frequency Oscillator O-373/FRN, block diagram.

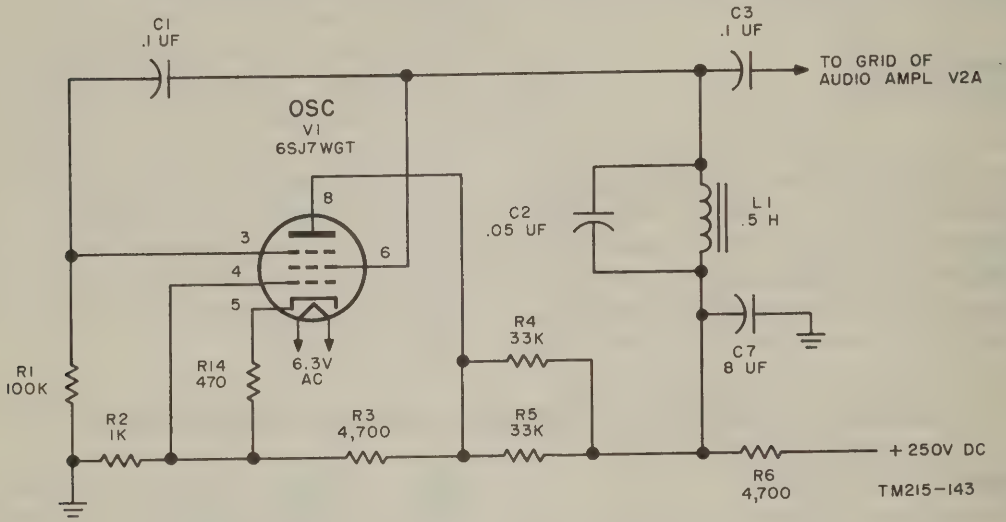


Figure 105. Oscillator V1, schematic diagram.

an oscillator. This is accomplished by operating the screen at a much higher potential than the plate and the suppressor grid more negative than the cathode. The suppressor grid is maintained at a negative potential by the voltage drop across resistor R1, which is produced by the feedback from the screen grid through capacitor C1.

b. The output of the oscillator is developed in a parallel-tuned circuit consisting of inductor L1 and capacitor C2 and coupled to the grid of audio amplifier V2A through capacitor C3.

c. Three different potentials of B+ for V1 are obtained from the series-parallel arrangement of bleeder resistors R2, R3, R4, R5, and R6. Resistor R14 in the cathode circuit maintains a slight difference in potential between the control grid and cathode. The audio signal in the screen circuit is bypassed to ground by filter capacitor C7.

122. Audio Amplifier V2A

(fig. 106)

Audio amplifier V2A uses one-half of a 6SN7WGTA to increase the 1,000-cycle tone signal from V1.

a. The input signal from V1, coupled through capacitor C3, is developed across grid resistor R11 and applied to the grid of V2A. The output signal is coupled through capacitor C4 to gain control R15.

b. Plate voltage for V2A is obtained from rectifier V3 through plate load resistor R10. Self-bias is developed across cathode resistor R9. Resistors R7 and R8 and capacitor C10, used in earlier models for keying purposes, are connected to ground through shorting plug P1 and receptacle J3 and have no function in the omnirange set.

123. Output Amplifier V2B

(fig. 106)

Output amplifier V2B uses one-half of a 6SN7WGTA to increase the 1,000-cycle tone signal from tube V2A.

a. The input signal from audio amplifier V2A, coupled through capacitor C4, is applied to gain control R15, then to the grid of V2B. The output signal is developed in the primary of transformer T1. The secondary provides a 500-ohm source for

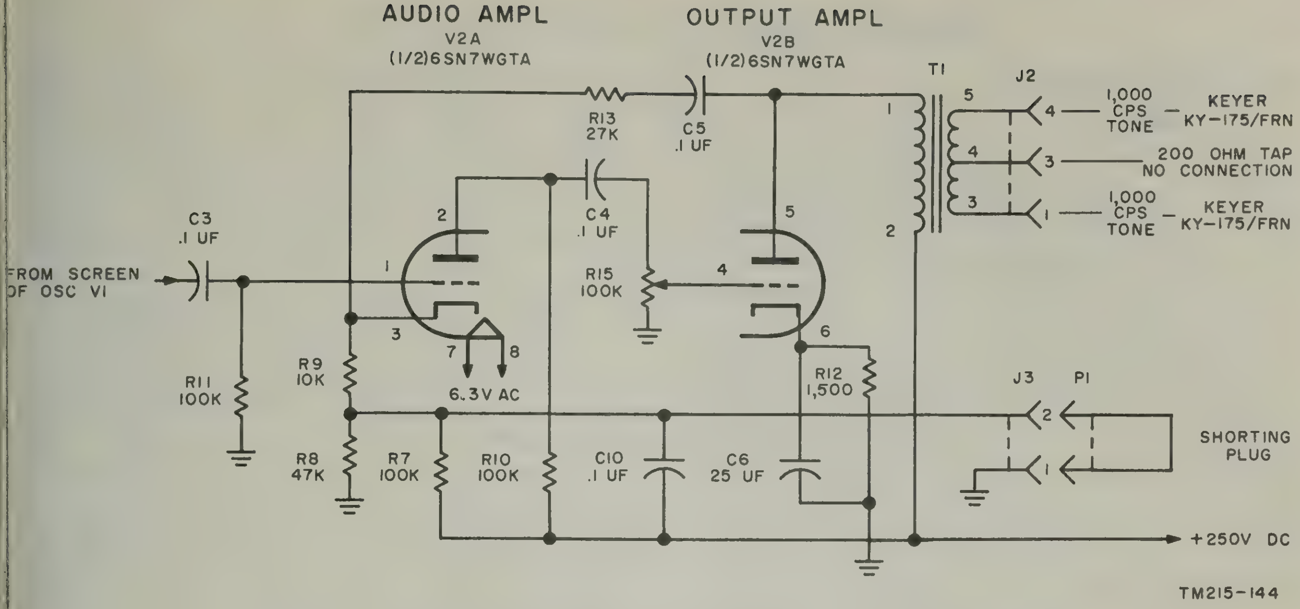


Figure 106. Audio amplifier V2A and output amplifier V2B, schematic diagram.

applying the signal through receptacle J2 to the keyer.

b. Plate voltage for V2B is obtained from rectifier V3 through the primary of transformer T1. Self-bias is developed across cathode resistor R12 which is bypassed by C6.

c. A degenerative feedback signal, to stabilize the amplifiers, is fed from the plate of V2B through capacitor C5 and resistor R13 to the cathode of V2A.

124. Rectifier V3

(fig. 107)

Rectifier V3 uses a 5V4G full-wave rectifier to supply operating voltages for the O–373/FRN.

a. The 115 volts ac from receptacle J1 is applied to transformer T2 through fuse F1. A center-tapped, high-voltage winding on the secondary of transformer T2 furnishes 325 volts ac to the plates of V3.

b. The output of V3 is filtered by a choke input filter consisting of chokes L2 and L3 and capacitors C8 and C9. The output of the filter is +250 volts dc.

c. Filament voltage for V3 is supplied by a 5-volt secondary winding on transformer T2. Filament voltage for V1 and V2 is supplied by a 6.3-volt secondary winding on transformer T2.

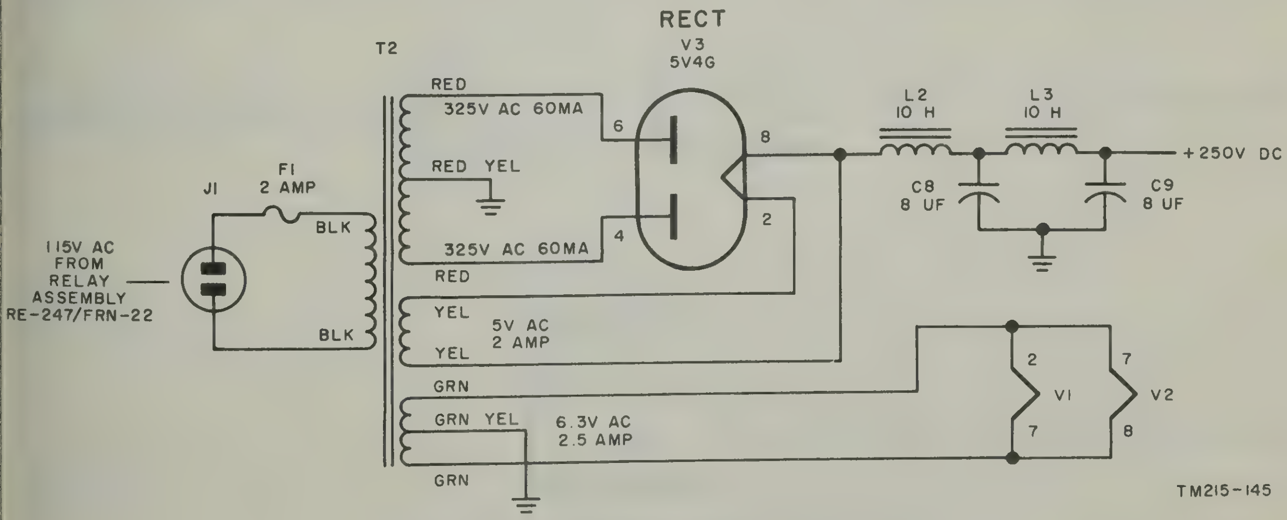


Figure 107. Rectifier V3, schematic diagram.

125. Block Diagram

(fig. 108)

The keyer is a motor-driven keying device which forms call letters by interrupting the 1,000-cycle tone signal produced by the O–373/FRN. The circuit is discussed in *a* and *b* below. For complete circuit details, refer to the overall schematic diagram (fig. 284).

a. Code switch S502 and cycle switch S501 have their contacts connected in series and are actuated by code wheel W1 and cycle wheel W2. When the contacts on both switches are closed, the 1,000 cycle tone signal from the O–373/FRN passes through the switch contacts to the RE–248/FRN–22. When the contacts on either switch are open, the 1,000-cycle tone is interrupted.

b. The 115-volt ac power for the operation of motor M501 is received from the RE–247/FRN–22. Motor M501 drives code wheel W1 directly and drives cycle wheel W2 through a gear train which has a 12–to–1 speed reduction ratio.

126. Signal Circuit

(fig. 109)

The signal circuit of the keyer interrupts the 1,000-cycle tone signal from the O–373/FRN and provides a constant impedance of approximately 500 ohms between the O–373/FRN–20 and the RE–248/FRN–22.

a. The 1,000-cycle output from the O–373/FRN is applied to the keyer through terminals 2 and 6 on terminal board TB501. Terminal 2 is a common input-output terminal. The 1,000-cycle tone is fed from terminal 6 to a fixed contact on code switch S502. The contact arm of code switch S502 has at its tip a small roller that rides on the circumference of code wheel W1. The circumference of code wheel W1 contains segments that must be removed to form the call letters. When the roller on the contact arm drops into a breakout, the switch contacts close and the 1,000-cycle tone is fed to the contact arm of cycle switch S501.

b. The contact arm of cycle switch S501 has at its tip a small roller that rides on the circumference of cycle wheel W2. Cycle wheel W2 rotates at one-twelfth the speed of code wheel W1. The circumference of cycle wheel W2 contains removable segments. The correct number of these segments must be broken out so that the roller on the contact arm of cycle switch S501 will drop into the breakouts and close the switch contacts for the length of time required for the call letters to be transmitted once. To repeat the call letters more than once for each revolution of cycle wheel W2, additional breakouts of the same length must be made around the circumference of cycle wheel W2.

c. When code switch S502 and cycle switch S501 close at the same time, the 1,000-cycle keyed tone is fed to the output circuit of the keyer. This output circuit consists of resistors R502, R503, and R504 connected in a T-network to provide a constant impedance of approximately 500 ohms whether or not the call letters are being transmitted. The 1,000-cycle tone output of the keyer, in the form of call letters, is fed through terminals 1 and 2 of terminal board TB501 to the RE–248/FRN–22.

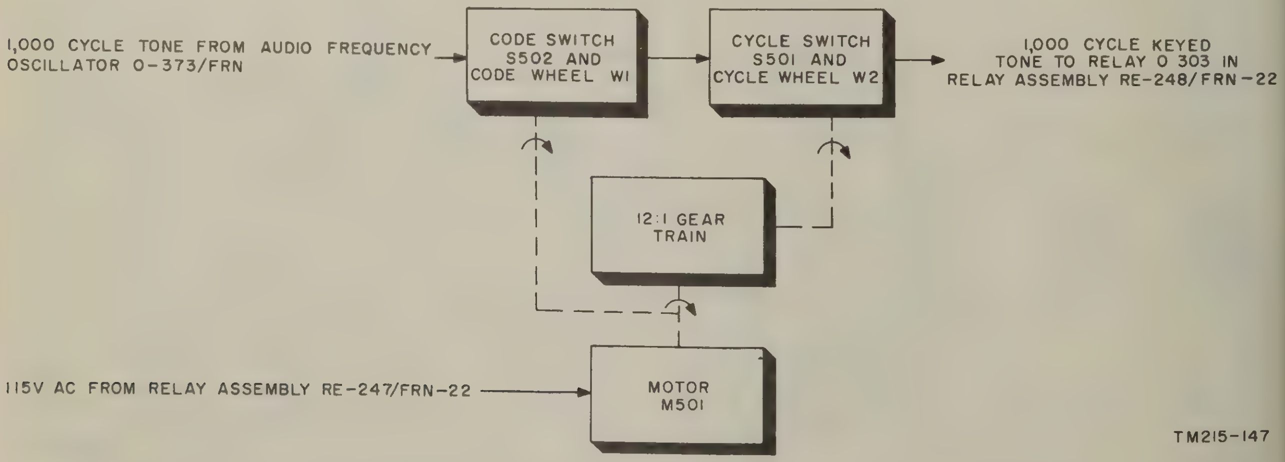

1,000 CYCLE TONE FROM AUDIO FREQUENCY OSCILLATOR O–373/FRN
CODE SWITCH S502 AND CODE WHEEL W1
CYCLE SWITCH S501 AND CYCLE WHEEL W2
1,000 CYCLE KEYED TONE TO RELAY O 303 IN RELAY ASSEMBLY RE–248/FRN–22
12:1 GEAR TRAIN
115V AC FROM RELAY ASSEMBLY RE–247/FRN–22
MOTOR M501
TM215–147

Figure 108. Keyer KY–175/FRN, block diagram.

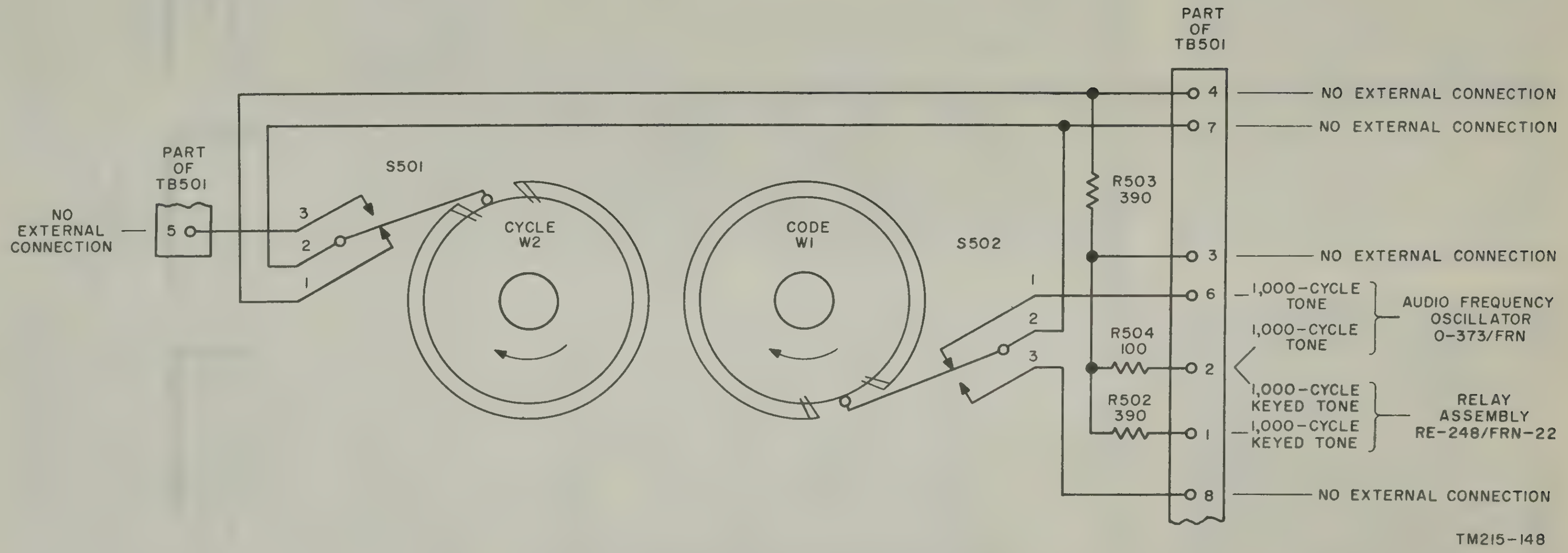


Figure 109. Keyer KY-175/FRN, signal circuit.

127. Code and Cycle Wheel Drive Assembly

(fig. 284, contained in separate envelope)

The drive assembly for the code and cycle wheels consists of a synchronous-type ac motor and a speed-reducing gear train.

a. A voltage of 115 volts ac from the RE–247/FRN–22 is applied through receptacle J501 and fuse F501 to motor M501. Capacitor C501 is a motor-phasing capacitor. Resistors R501 and R505, which were used in an earlier model, are shortened and have no function when the keyer is used in the omnirange set.

b. Motor M501 has an internal speed-reducing gearbox that reduces the speed of the power takeoff shaft to 7.2 rpm when the motor is operating from 60-cycle power or 6 rpm with the motor operating from 50-cycle power.

c. Code wheel W1 and a 20-tooth gear are mounted on the power takeoff shaft. The 20-tooth gear engages with an 80-tooth gear to drive a 32-tooth gear. The 32-tooth gear engages a 96-tooth gear to drive cycle wheel W2 at 0.6 rpm when motor M501 operates on 60-cycle power or 0.5 rpm when motor M501 operates on 50-cycle power.

Section XIII. THEORY OF ANTENNA GROUP AN/FRA–14

128. Block Diagram

(fig. 110)

Antenna Group AN/FRA–14 continuously samples and detects the RF signal radiated by the antenna. The detected signal is fed to the monitor. The signal path is shown in the block diagram and is discussed in *a* through *c* below. For complete circuit details, refer to the overall schematic diagram (fig. 111).

a. The RF signal received by the AN/FRA–14 antenna is matched to push-pull diode detector V1 by a tunable VHF band-pass filter.

b. The output of V1 is developed across a resistive load and fed through a coaxial cable to the monitor.

c. The 115-volt ac operating power for the AN/FRN–14 is supplied by the RE–247/FRN–22.

129. Detector V1

(fig. 111)

Detector V1 uses a 6AL5W twin diode to detect the RF signal received by antenna E1. The output of V1 is fed to the monitor.

a. Antenna E1 is a folded dipole with a range from 108 to 118 mc. The output terminals of antenna E1 are connected to balanced taps on step-up inductor L1.

b. A parallel-tuned circuit consisting of inductor L1 and capacitor C1 tunes to any frequency from 108 to 118 mc. The RF signal tuned by inductor L1 and capacitor C1 is fed to the plates of V1 which operates as a full-wave detector. The cathodes of V1 are connected together. The detected signal voltage appears across load resistor R1. The detected signal consisting of either navigational information and identification tone or navigational information and voice communications is fed through receptacle J2 and a coaxial cable to the monitor.

c. The 115-volt ac operating power from the RE–247/FRN–22 is applied through receptacle J1 and current-limiting resistor R2 to filament transformer T1. The secondary winding of transformer T1 supplies 6.3 volts ac for the filament of tube V1. The filament of V1 is bypassed by capacitor C2 to prevent stray RF circulating currents and to reduce the noise effect of stray pickup in the powerline.

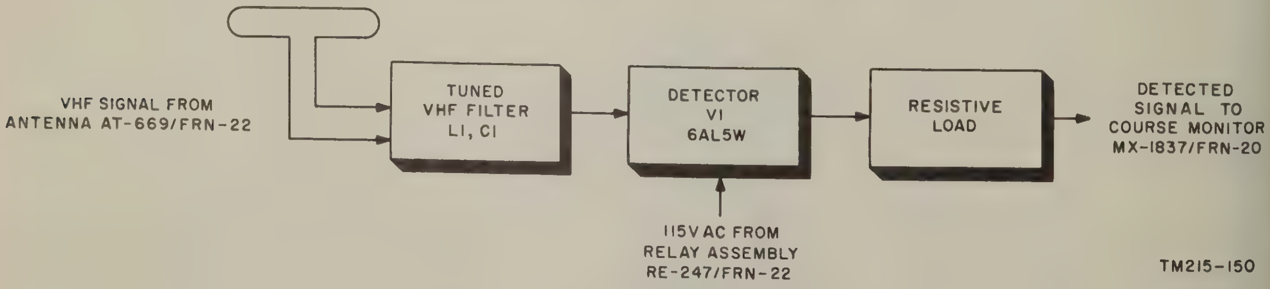
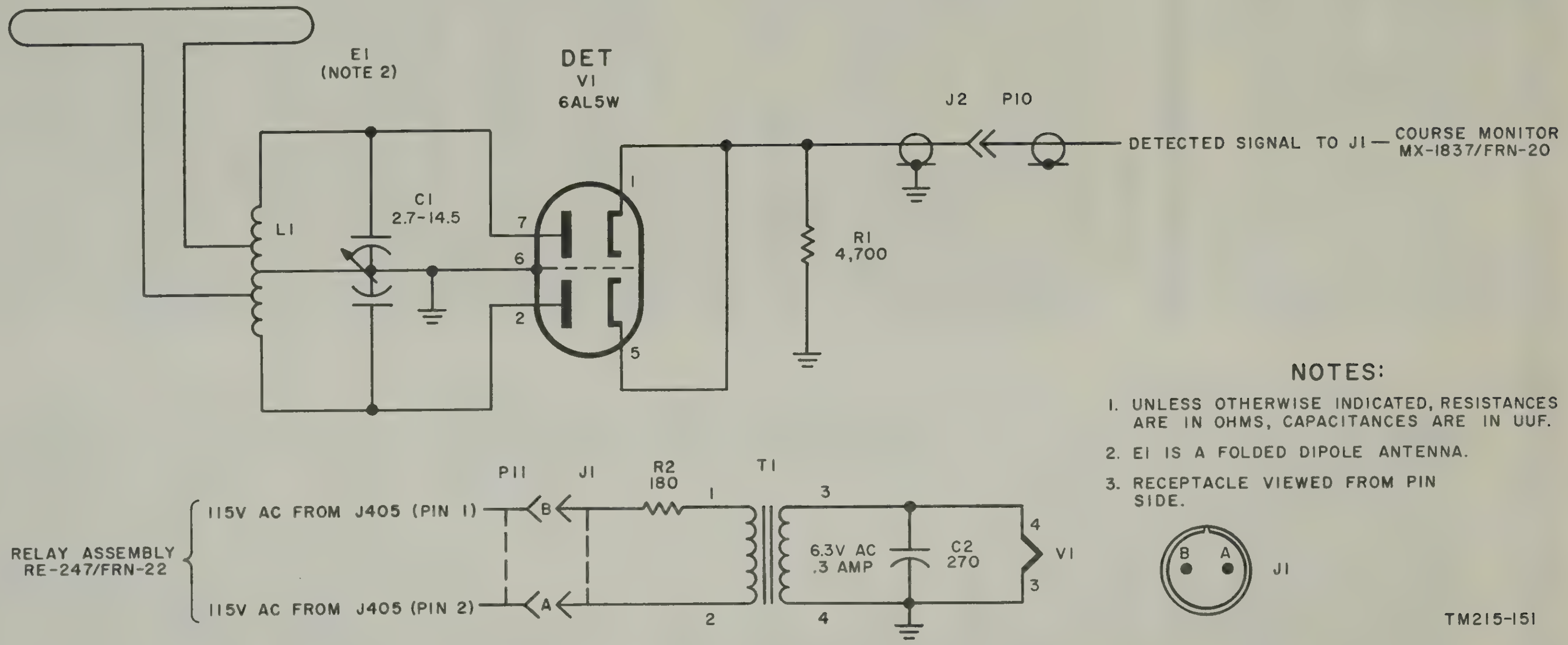


Figure 110. Antenna Group AN/FRA–14, block diagram.


E1
(NOTE 2)
DET
V1
6AL5W
J2
P10
DETECTED SIGNAL TO J1 — COURSE MONITOR MX-1837/FRN-20
L1
C1
2.7-14.5
7
6
2
1
5
R1
4,700
P11
J1
R2
180
T1
1
2
3
4
RELAY ASSEMBLY RE-247/FRN-22
115V AC FROM J405 (PIN 1)
115V AC FROM J405 (PIN 2)
B
A
6.3V AC
.3 AMP
C2
270
4
3
V1
B
A
J1
TM215-151

NOTES:

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. E1 IS A FOLDED DIPOLE ANTENNA.
3. RECEPTACLE VIEWED FROM PIN SIDE.

Figure 111. Antenna Group AN/FRA-14, schematic diagram.

130. Block Diagram

(fig. 112, contained in separate envelope)

Course Monitor MX–1837/FRN–20 receives the demodulated signal from the AN/FRA–14. The monitor compares the navigational components of the signal with preset standards for input level, phase relationship, and amplitude. The detected signal also provides fail-safe protection and is amplified for aural monitoring. The monitor consists of reference, variable, and audio signal circuits, a phase comparator, a vacuum-tube voltmeter (vtvm), an alarm relay, and a power supply. The signal paths and circuits are discussed in paragraphs 131 through 136. For complete circuit details, refer to the schematic diagram (fig. 285, contained in separate envelope).

131. Reference Signal Circuit Block Diagram

(fig. 112, contained in separate envelope)

The reference signal circuit selects, amplifies, and detects the subcarrier signal. The signal level is compared at two different points in the channel against a preset level. If comparison shows a signal level drop below the preset level, an alarm will occur. The output is fed to the phase comparator circuit.

a. The input signal is fed through the fail-safe circuit which consists of COURSE RELAY meter M2 and COURSE INDICATOR meter M1 in the phase comparator circuit. First amplifier V2B selects and amplifies the subcarrier signal only. The output of V2B is fed to LEVEL switch S1 for amplitude measurements and to second amplifier V1B for additional amplification. The output of V1B is fed to reference level alarm detector V6B and limiter V1A.

b. Reference level alarm detector V6B rectifies the signal and feeds the positive half-cycle to reference level alarm thyratron V17. The V17 current flows through and energizes the reference level alarm relay.

c. The signal received at limiter V1A from V1B is amplified and the peaks are clipped to remove any amplitude modulation. The output of V1A is fed to slope detector V8B. Slope detector V8B demodulates the subcarrier signal to obtain the reference 30-cycle signal. This signal is amplified by third amplifier V4B and output amplifier V12. The signal from V12 is fed to reference fail-safe alarm detector V8A and to the phase comparator circuit for comparison with the variable 30-cycle signal.

d. Reference fail-safe alarm detector V8A rectifies the signal and feeds the positive half-cycle to reference fail-safe alarm thyratron V18. The V18 current flows through and energizes alarm relay RY4.

132. Variable Signal Channel, Block Diagram

(fig. 112, contained in separate envelope)

The variable-signal circuit selects, amplifies, and shifts the phase of the variable 30-cycle signal. The signal level is compared at two different points against a preset level. If comparison shows a signal level drop below the preset level, an alarm will occur. Output of the variable signal circuit is fed to the phase comparator circuit.

a. Variable signal circuit input amplifier V2A selects and increases the variable 30-cycle signal. The output of V2A is fed to inverter V4A, level alarm amplifier V3A, and the vtvm circuit for a level indication.

b. Variable level alarm amplifier V3A amplifies the variable 30-cycle signal and feeds variable level alarm detector V7A. Tube V7A rectifies the signal and feeds the positive half-cycles to variable level alarm thyratron V16. The output current of V16 flows through and energizes alarm relay RY4.

c. The variable 30-cycle signal is fed to inverter V4A which produces two outputs 180° out of phase. The two outputs are applied to the phase-shift network which consists of phase selector switch S4 and PHASE ZERO control R72. Switch S4 and control R72 are adjusted to produce exactly 90° phase difference between the variable 30-cycle signal channel and the reference 30-cycle signal channel. The output of the phase-shift network is fed to controlled amplifier V5 and to agc amplifier V3B where it is amplified and fed to agc detector V6A. Tube V6A detects the signal and develops a negative bias to control the operating point of tube V5. The agc circuit is necessary because the output of the phase-shift network varies at different settings of phase selector switch S4. Tube V5 and output amplifier V11 increase the signal received from the phase-shift network. The signal from output amplifier V11 is fed to variable fail-safe alarm detector V7B and phase comparator circuit for comparison with the reference 30-cycle signal.

d. Variable fail-safe alarm detector V7B rectifies the signal and feeds the positive half-cycles to variable fail-safe alarm thyratron V15. The output current of V15 flows through and energizes alarm relay RY4.

133. Audio Signal Circuit Block Diagram

(fig. 112)

The audio signal circuit receives a portion of the detected signal input from the AN/FRA–14. The signal is amplified by first audio amplifier V9A and audio output amplifier V9B to a sufficient level to drive a headset. The keyed tone can be heard on the handset at the remote location. The subcarrier signal will normally not be heard at the remote location because of the attenuation of the telephone line.

134. Phase Comparator Circuit, Block Diagram

(fig. 112)

The phase comparator circuit is a balanced-bridge detector. The circuit receives the reference 30-cycle signal from the reference signal circuit and the variable 30-cycle signal from the variable signal circuit. The phase difference of the two signals results in a current with amplitude and polarity determined by the amount of phase difference. The resultant output is fed to COURSE RELAY meter M2 and COURSE INDICATOR meter M1 connected in series across the output of the phase comparator circuit.

135. Vacuum-Tube Voltmeter Circuit, Block Diagram

(fig. 112)

The vacuum-tube voltmeter circuit is used when adjusting and maintaining the monitor. The input to the vtvm circuit is through LEVEL switch S1, which selects the signal to be measured. The signal selected is then routed through cathode follower V13A to amplifier V13B. The amplified output of tube V13B is rectified by meter rectifier V14 and applied to level meter M3.

136. Power Supply, Circuit, Block Diagram

(fig. 112)

The power supply circuit provides —6 volts dc to bias the alarm thyratrons and a regulated +250 volts dc for the plates and screens of all the tubes in the monitor. The 115-volt ac input is applied to rectifier V10. The dc output of V10 is applied to series regulator V21 and V22. The output of V21 and V22 is the regulated +250 volts dc. Voltage regulator V20 and regulator amplifier V19 control the operating voltages applied to series regulator V21 and V22.

137. First Amplifier V2B

(fig. 113)

First amplifier V2B uses one-half of a 12AX7 twin triode to increase the subcarrier signal.

a. The input signal from the AN/FRA–14 is applied through receptacle J1 to INPUT LEVEL control R1 to permit calibration of the input level to the monitor. The signal is then coupled through capacitor C24 to the fail-safe loop which consists of COURSE RELAY meter M2 in series with COURSE INDICATOR meter M1. If either of these meters was faulty, a course error alarm would never occur. Therefore, by coupling the reference channel input signal through these meters as a safety factor, a reference level alarm does occur if either of the meters is faulty.

b. The signal from the fail-safe loop is coupled through capacitor C1 to a band-pass filter consisting of inductor L1, variable capacitor C2, and fixed capacitor C3. The output of the band-pass filter is the subcarrier signal which is coupled through capacitor C4 to the grid of V2B. Capacitors C1 and C4 offer a very high reactance to the 1,000-cycle tone and the variable 30-cycle signal and a fairly low reactance to the subcarrier signal.

c. The subcarrier signal is amplified in V2B and coupled through capacitor C6 and REF LEVEL control R5, and appears across REF CAL control R6. Plate voltage is obtained from the power supply through plate load resistor R4. Resistor R2 is the grid load resistor. Self-bias is developed across cathode resistor R3, which is bypassed by capacitor C5.

d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

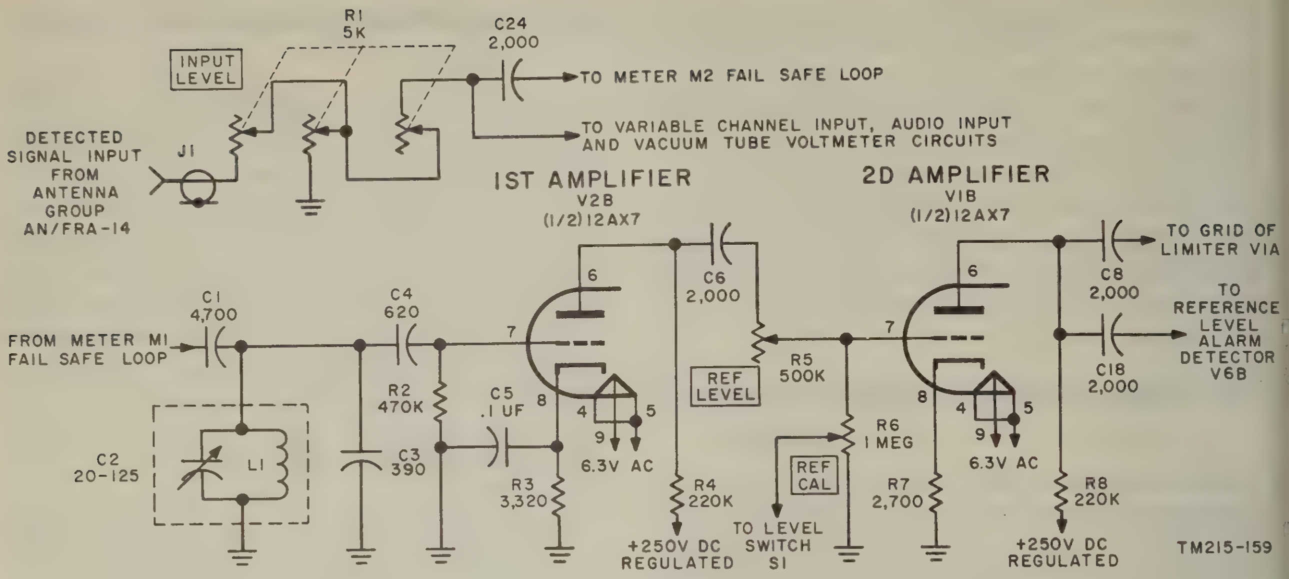


Figure 113. First amplifier V2B and second amplifier V1B, schematic diagram.

138. Second Amplifier V1B

(fig. 113)

Second amplifier V1B uses one-half of a 12AX7 twin triode to further increase the subcarrier signal.

a. The input signal from REF LEVEL control R5 and REF CAL control R6 is applied to the grid. The output signal developed across plate load resistor R8 is coupled through capacitor C8 to limiter V1A and through capacitor C18 to reference level alarm detector V6B.

b. Plate voltage is obtained from the power supply through plate load resistor R8. Self-bias is developed across cathode resistor R7. A portion of the input signal is tapped off by the arm of REF CAL control R6 and fed to LEVEL switch S1 for level monitoring.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

139. Limiter V1A

(fig. 114)

Limiter V1A uses one-half of a 12AX7 twin triode to remove any amplitude modulation from the subcarrier signal.

a. The input signal from second amplifier V1B, coupled through capacitor C8, is applied to the grid of limiter V1A. The amplitude of the signal across grid resistor R9 is sufficient to bias tube V1A beyond cutoff during negative peaks of the signal. The positive peaks drive the tube beyond the saturation point; therefore limiting occurs at both the positive and negative peaks, removing any amplitude modulation.

b. The output signal, developed across plate load resistor R10, is coupled through capacitor C9 to slope detector V8B. Plate voltage is obtained from the power supply through R10.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

140. Slope Detector V8B

(fig. 114)

Slope detector V8B uses one-half of a 6AL5W twin diode to demodulate the subcarrier signal and recover the reference 30-cycle signal.

a. The output signal from limiter V1A, coupled through capacitor C9, is applied to a tuned circuit (inductor L2 and capacitors C10 and C11) and the plate of tube V8B. The tuned circuit is adjusted by variable capacitor C10 to a frequency of 11 kc. The 11-kc frequency is selected above the subcarrier signal frequency to obtain the correct phase relationship required in the output. Because of the resonant frequency selected, the applied 9,960-cycle subcarrier, frequency-modulated at a 30-cycle rate, will be centered on the low-frequency slope side of the tuned-circuit, resonant-frequency curve. As the subcarrier frequency is increased by modulation above the 9,960-cycle center frequency, the voltage developed across the tuned circuit will increase in proportion to the rate of frequency change. When the subcarrier frequency is decreased, the voltage across the tuned circuit will decrease. The frequency-modulated subcarrier is converted to an amplitude-modulated subcarrier as the tuned-circuit impedance varies with frequency changes.

b. Tube V8B rectifies the amplitude-modulated subcarrier and develops the 30-cycle signal across diode load resistor R11. The 9,960-cycle carrier is filtered out by capacitors C12 and C13 and resistor R12, and the reference 30-cycle signal is coupled to third amplifier V4B through capacitor C14.

c. Filament voltage for tube V8B is obtained from a 6.3-volt secondary winding on power supply transformer T4.

141. Third Amplifier V4B

(fig. 115)

Third amplifier V4B uses one-half of a 12AX7 twin triode to amplify the reference 30-cycle signal.

a. The signal from slope detector V8B, coupled through capacitor C14, is attenuated by a voltage divider consisting of grid resistors R13 and R14 and applied to the grid. The output signal developed across plate load resistor R16 is coupled through capacitor C15 to output amplifier V12.

b. Plate voltage is obtained from the power supply through plate load resistor R16. Self-bias is developed across cathode resistor R15.

c. Filament voltage for tube V4B is obtained from a 6.3-volt secondary winding on transformer T4.

142. Output Amplifier V12

(fig. 115)

Output amplifier V12 uses a 6C4WA triode to further increase the reference 30-cycle signal and to feed the phase comparator circuit.

a. The signal from third amplifier V4B is applied across grid resistor R17 to the grid of V12. The output signal developed in transformer T1 is fed to the phase comparator circuit. Capacitor C21 couples the signal to reference fail-safe alarm detector V8A.

b. Capacitor C16 filters out noise pulses and prevents any tendency to high-frequency oscillations. TEST switch S2 shorts the grid circuit to ground when held in the REF position. This removes the signal voltage during phase comparator circuit balancing adjustments.

c. Plate voltage is obtained from the power supply through transformer T1. Capacitor C17 is shunted across the primary of T1 to reduce harmonic distortion. Self-bias is developed across cathode resistor R18.

d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

143. Reference Level Alarm Detector V6B

(fig. 116)

Reference level alarm detector V6B uses one-half of a 6AL5W twin diode to rectify the subcarrier signal used to control reference level alarm thyratron V17.

a. The subcarrier signal from second amplifier V1B, coupled through capacitor C18, is applied to the cathode. The plate is grounded. The positive voltage developed across REF ALARM

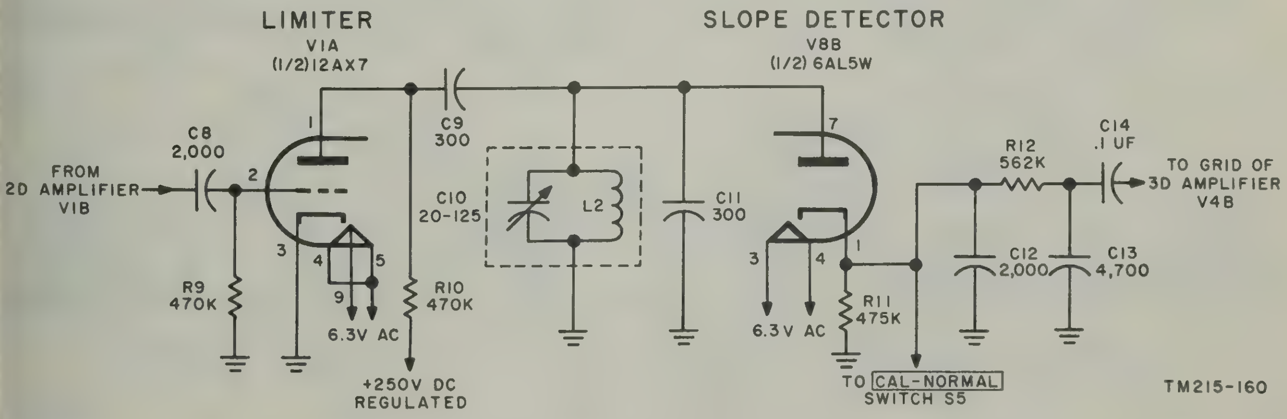


Figure 114. Limiter V1A and slope detector V8B, schematic diagram.

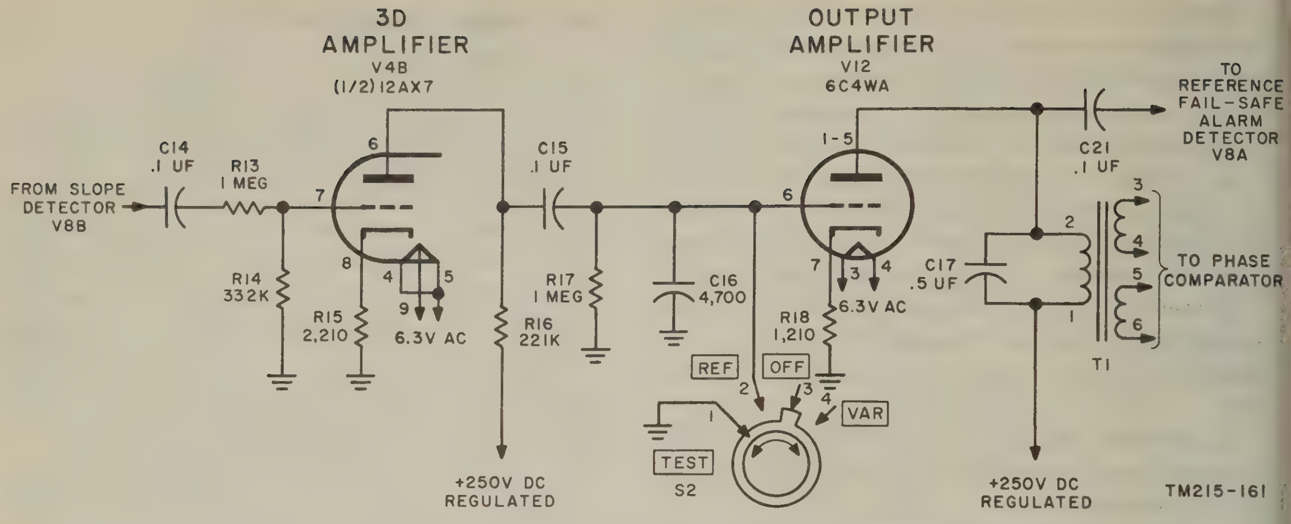


Figure 115. Third amplifier V4B and output amplifier V12, schematic diagram.

control R19 is fed through a low-pass filter, which consists of resistor R20 and capacitor C19, to reference level alarm thyratron V17.

b. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

144. Reference Level Alarm Thyratorn V17

(fig. 116)

Reference level alarm thyratron V17 uses a 5696 thyratron to operate reference alarm relay RY3.

a. The rectified signal from V6B, coupled through the low-pass filter, is applied through protective resistor R22 to the grid. A negative bias of —6 volts dc is obtained from the power supply through grid resistor R21. REF ALARM control R19 is adjusted with a preset signal input to V6B to reduce the negative fixed bias and allow thyratron V17 to conduct, and energize reference alarm relay RY3. Any decrease in signal input will cause the negative fixed bias to cut off thyratron V17 and deenergize relay RY3.

b. Plate voltage of 115 volts ac is obtained from a secondary winding of transformer T4 through the coil of reference alarm relay RY3 and current-limiting resistor R23. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

c. The coil of reference alarm relay RY3 is shunted by capacitor C20, which charges and holds relay RY3 energized between pulses of the rectified subcarrier signal applied to the grid. Contacts 1R and 2R of relay RY3, current-limiting resistor R24, and REF ALARM indicator I 3 connect in series across a 6.3-volt secondary winding on transformer T4. Contacts 3R and 4R of

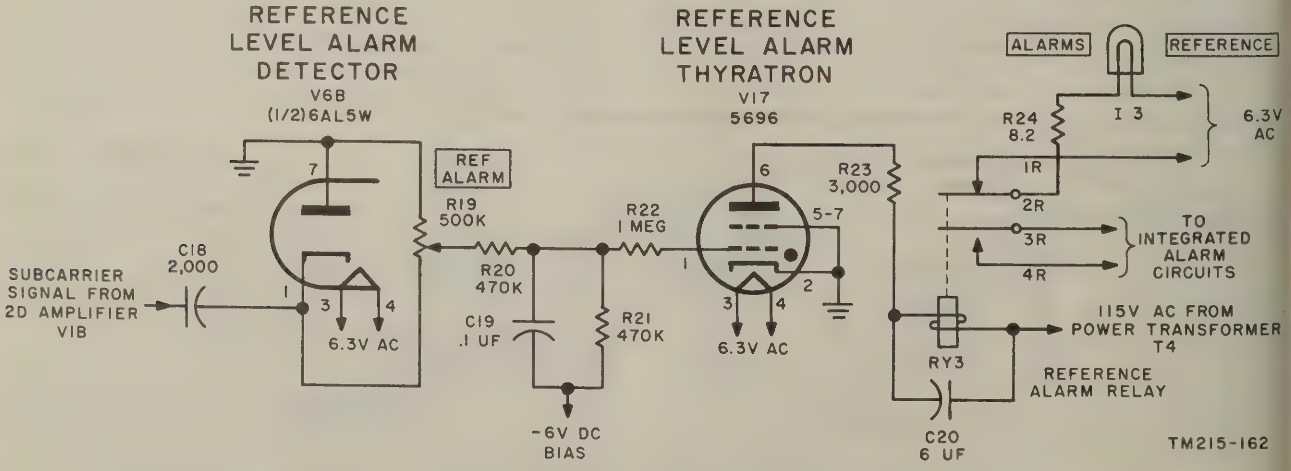


Figure 116. Reference level alarm detector V6B and reference level alarm thyratron V17, schematic diagram.

RY3 are connected in series with the 115 volts ac to the plate of reference fail-safe alarm thyratron V18. When RY3 deenergizes, the 115-volt circuit to V18 is opened and the 6.3-volt circuit is closed, causing REF ALARM indicator I 3 to light.

145. Reference Fail-Safe Alarm Detector V8A

(fig. 117)

Reference fail-safe alarm detector V8A uses one-half of a 6AL5W twin diode to rectify the reference 30-cycle signal that controls reference fail-safe alarm thyratron V18.

a. The reference 30-cycle signal from output amplifier V12, coupled through capacitor C21, is applied to the cathode. The plate is grounded. The positive voltage developed by cathode resistor R25 is fed through a low-pass filter consisting of resistor R26 and capacitor C22 to reference fail-safe alarm thyratron V18.

b. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

146. Reference Fail-Safe Alarm Thyratron V18

(fig. 117)

Reference fail-safe alarm thyratron V18 uses a 5,696 thyratron to energize course alarm relay RY4.

a. The rectified signal from V8A is applied through protective resistor R28 to the grid of tube V18. A negative bias of —6 volts dc, obtained from the power supply through grid resistor R27, will cut off thyratron V18 when the rectified signal output of detector V8A drops below the preset level.

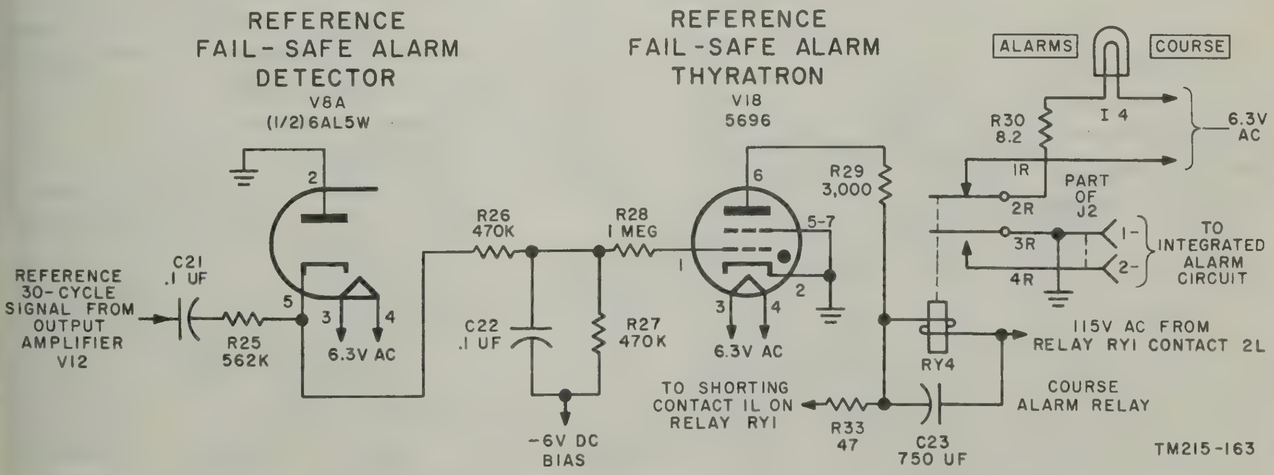
b. Plate voltage of 115 volts ac is obtained from a secondary winding of transformer T4 through current-limiting resistor R29, the coil of course alarm relay RY4, contacts of phase alarm relay RY1, contacts of variable alarm relay RY2, contacts of reference alarm relay RY3, and the contacts of bias relay RY5. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

c. The coil of course alarm relay RY4 is shunted by capacitor C23, which charges and holds relay RY4 energized between pulses of the rectified reference 30-cycle signal applied to the grid. Contacts 1R and 2R of relay RY4, current-limiting resistor R30, and COURSE ALARM indicator I 4 are connected across a 6.3-volt secondary winding on transformer T4. Contacts 3R and 4R furnish a ground return for relay O 206 in the remote control unit and for relay K601 in Radio Set Transfer Control C–1840/FRN–22. When relay RY4 deenergizes, the 6.3-volt circuit is closed, causing COURSE ALARM indicator I 4 to light. The ground return circuit for relays O206 and K601 is opened, causing the transmitting equipment to turn off and the transfer cycle to start.

147. Input Amplifier V2A

(fig. 118)

Input amplifier V2A uses one-half of a 12AX7 twin triode to increase the variable 30-cycle signal.



REFERENCE FAIL-SAFE ALARM DETECTOR
V8A
(1/2) 6AL5W
REFERENCE FAIL-SAFE ALARM THYRATRON
V18
5696
ALARMS
COURSE
I 4
R30
8.2
6.3V AC
R29
3,000
1R
2R
3R
4R
PART OF J2
1-
2-
TO INTEGRATED ALARM CIRCUIT
2
5
3
4
6
5-7
1
2
3
4
REFERENCE 30-CYCLE SIGNAL FROM OUTPUT AMPLIFIER V12
C21
.1 UF
R25
562K
6.3V AC
R26
470K
R28
1 MEG
C22
.1 UF
R27
470K
-6V DC BIAS
6.3V AC
115V AC FROM RELAY RY1 CONTACT 2L
RY4
TO SHORTING CONTACT 1L ON RELAY RY1
R33
47
C23
750 UF
COURSE ALARM RELAY
TM215-163

Figure 117. Reference fail-safe alarm detector V8A and reference fail-safe alarm thyratron V18, schematic diagram.

a. The signal from attenuator R1 is fed through NORMAL-CAL switch S5, in NORMAL position, to a low-pass filter. The low-pass filter, which consists of resistor R43 and capacitor C27, filters out the subcarrier signal and the 1,000-cycle tone. The variable 30-cycle signal is coupled through capacitor C28 to the grid of input amplifier V2A. Resistor R44 is the grid load resistor. The output signal of V2A, developed across plate-load resistor R46, is coupled through capacitor C30 to VAR LEVEL control R47.

b. Plate voltage is obtained from the power supply through plate-load resistor R46. Self-bias is developed across cathode resistor R45, which is bypassed by capacitor C29.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

148. Level Alarm Amplifier V3A

(fig. 118)

Level-alarm amplifier V3A uses one-half of a 12AX7 twin triode to increase the variable 30-cycle signal enough to control the variable level alarm.

a. The signal from input amplifier V2A is developed across VAR LEVEL control R47. The arm of VAR CAL control R48 connects to LEVEL switch S1. The output of V3A, developed across plate load resistor R90, is coupled through capacitor C47 to variable level alarm detector V7A.

b. Plate voltage for V3A is obtained from the power supply circuits through R90. Self-bias is developed across cathode resistor R89.

c. Filament voltage is obtained from a 6.3-volt secondary winding transformer T4.

149. Inverter V4A

(fig. 119)

Inverter V4A uses one-half of a 12AX7 twin triode to furnish two outputs equal in amplitude and opposite in phase.

a. The variable 30-cycle signal from VAR LEVEL control R47 through coupling capacitor C32 is applied to the grid. Grid resistor R49 connects between the grid and the junction of cathode resistors R50 and R51 to obtain the correct grid bias.

b. The output signal developed across plate-load resistor R52 and fed through coupling capacitor C34 to the phase-shift network is equal in amplitude but opposite in phase to the output signal developed across cathode resistor R51 and fed through coupling capacitor C33 to the phase-shift network.

c. Plate voltage is obtained from the power supply circuit through plate load resistor R52. Self-bias is developed across cathode resistors R50 and R51.

d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

150. Phase-Shift Network

(fig. 119)

The phase-shift network, consisting of phase-selector switch S4, resistors R54 through R71, and PHASE ZERO control R72, is used to shift

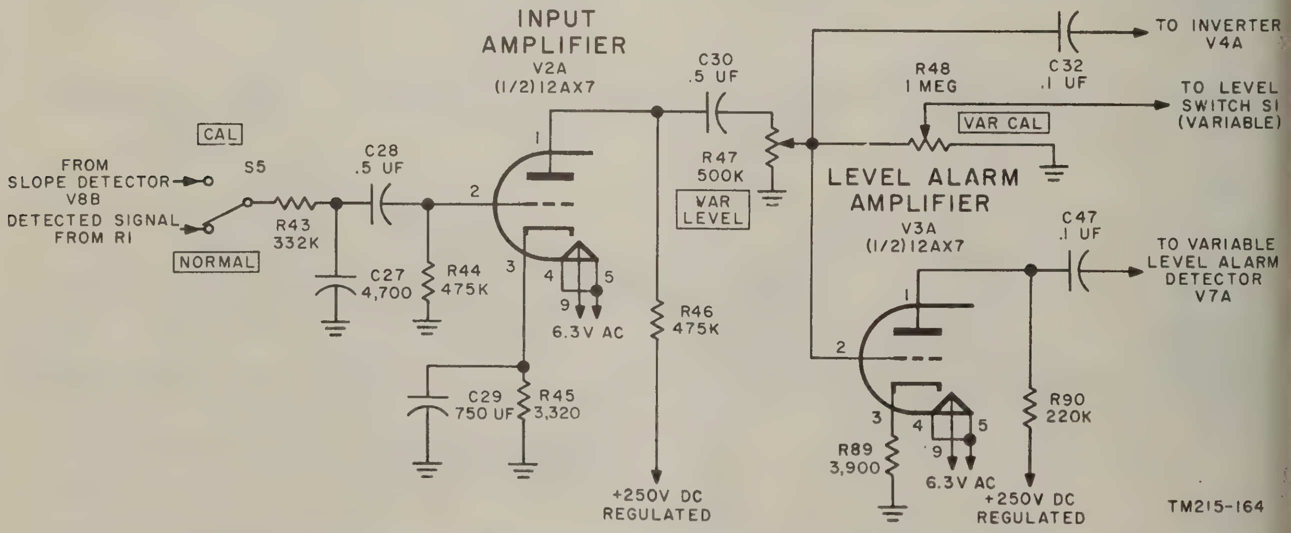


Figure 118. Input amplifier V2A and level alarm amplifier V3A, schematic diagram.

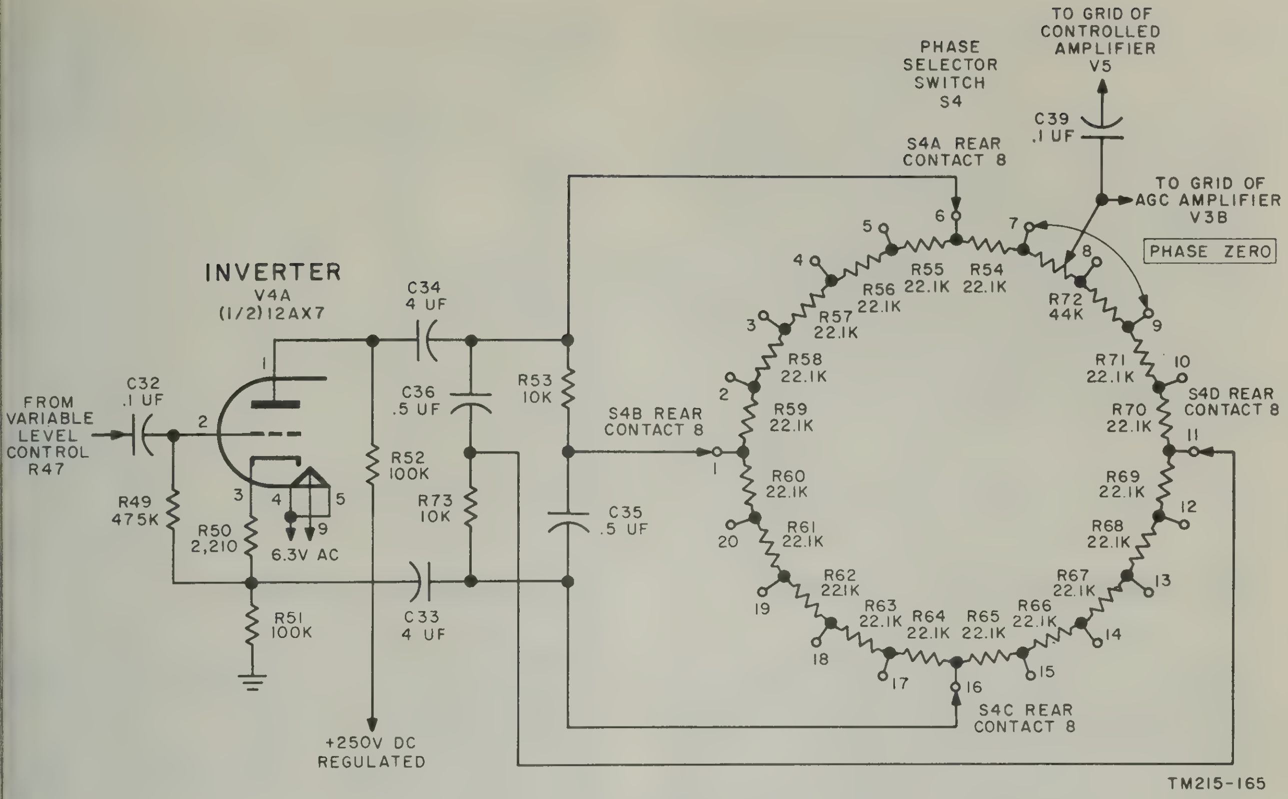


Figure 119. Inverter V4A and phase-shift network, schematic diagram.

the phase of the variable 30-cycle signal the amount required through a 360° range.

a. The variable 30-cycle signal from the plate circuit of V4A, coupled through capacitor C34, is applied to the first section rotor of S4. This plate output signal is also shifted 90° by capacitor C36 and resistor R73 and applied to the fourth section rotor of switch S4, which has the rotor contact displaced 90° mechanically from the first section rotor. The variable 30-cycle signal from the cathode circuit of V4A, coupled through capacitor C33, is applied to the third section rotor of switch S4. This cathode output signal is also shifted 90° by capacitor C35 and resistor R53 and applied to the second section rotor of switch S4, which is displaced 90° mechanically from the third section rotor.

b. A single output is obtained by connecting the four quadrature signals (0, 90, 180, and 270°) to the resistive bridge consisting of switch S4, mounted resistors R54 through R71, and PHASE ZERO control R72. Output from the bridge is taken from the arm of PHASE ZERO control R72, which is used for vernier phase adjustments. Coarse phase adjustments are made in increments of 18° by rotation of switch S4. The settings of switch S4 and PHASE ZERO control R72 are determined by the location of Antenna Group AN/FRA–14.

c. The variable 30-cycle signal output from the arm of PHASE ZERO control R72 is applied to the grid of agc amplifier V3B and coupled through capacitor C39 to the grid of controlled amplifier V5.

151. Agc Amplifier V3B

(fig. 120)

Agc amplifier V3B uses one-half of a 12AX7 twin triode to increase the variable 30-cycle signal received from PHASE ZERO control R72.

a. The signal is applied to the grid of V3B. Resistor R74 is the grid load resistor. The output signal developed across plate load resistor R76 is coupled through capacitor C38 to agc detector V6A.

b. Plate voltage is obtained from the power supply circuit through plate load resistor R76. Self-bias is developed across cathode resistor R75, which is bypassed by capacitor C37.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

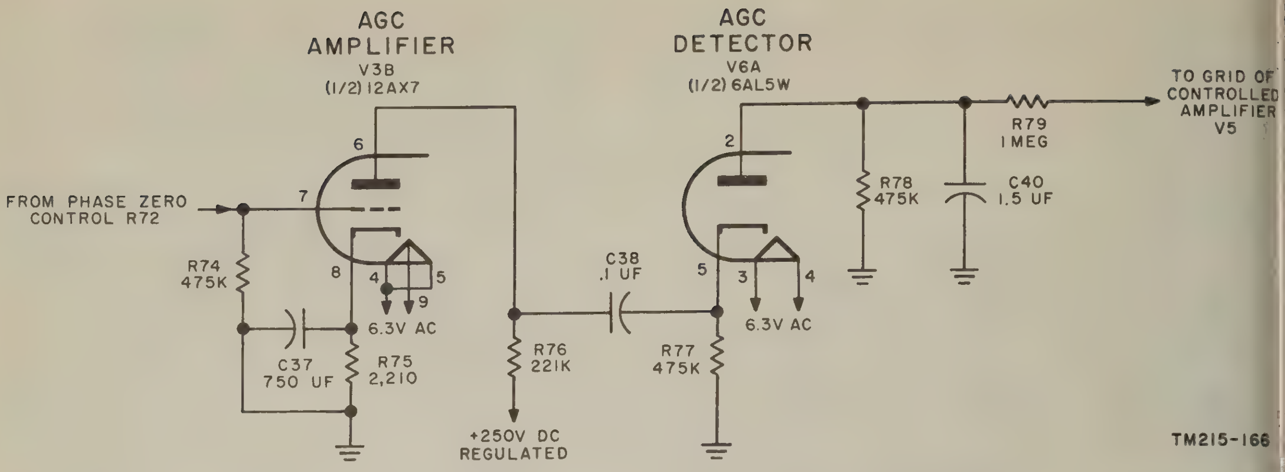


Figure 120. Agc amplifier V3B and agc detector V6A, schematic diagram.

152. Agc Detector V6A

(fig. 120)

Agc detector V6A uses one-half of a 6AL5W twin diode to rectify the variable 30-cycle signal and provide a negative bias to control the operation of controlled amplifier V5.

a. The input signal from V3B, coupled through capacitor C38, is applied to V6A across cathode resistor R77. The negative output voltage, developed across plate load resistor R78 and filtered by capacitor C40, is connected through resistor R79 to the grid of controlled amplifier V5.

b. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

153. Controlled Amplifier V5

(fig. 121)

Controlled amplifier V5 uses a 6BA6 pentode to amplify the variable 30-cycle signal from PHASE ZERO control R72.

a. The signal from PHASE ZERO control R72, coupled through capacitor C39, is applied to the grid. The output signal, which is controlled by the agc bias applied to the grid of V5 through isolation resistor R79, is developed across plate load resistor R80 and coupled through capacitor C42 to output amplifier V11.

b. Plate voltage is obtained from the power supply through plate load resistor R80. Screen

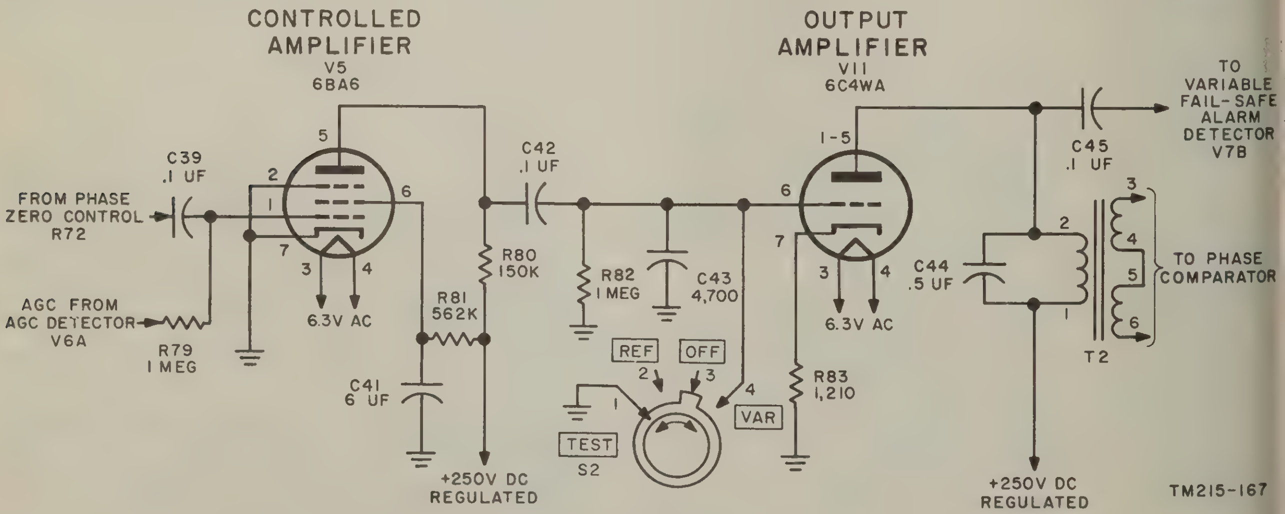


Figure 121. Controlled amplifier V5 and output amplifier V11, schematic diagram.

voltage is obtained from the power supply through screen-dropping resistor R81. The screen is bypassed to ground by capacitor C41.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

154. Output Amplifier V11

(fig. 121)

Output amplifier V11 uses a 6C4WA triode to further increase the variable 30-cycle signal and to feed the phase comparator circuit.

a. The signal from controlled amplifier V5, coupled through capacitor C42, is applied across grid resistor R82 and to the grid of V11. The output signal developed in transformer T2 is coupled to the phase comparator circuit and through capacitor C45 to variable fail-safe alarm detector V7B.

b. Capacitor C43, connected from grid to ground, filters out noise pulses and prevents any tendency for high-frequency oscillations to be developed in the amplifier. TEST switch S2 shorts the grid circuit to ground when held in VAR position. This action removes the signal voltage during phase comparator circuit balancing adjustments.

c. Plate voltage for V11 is obtained from the power supply through transformer T2. Capacitor C44 is shunted across the primary of transformer T2 to reduce harmonic distortion. Self-bias is developed across cathode resistor R83.

d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

155. Variable Level Alarm Detector V7A

(fig. 122)

Variable level alarm detector V7A uses one-half of a 6AL5W twin diode to rectify the variable 30-cycle signal used to control variable level alarm thyratron V16.

a. The variable 30-cycle signal from level alarm amplifier V3A, coupled through capacitor C47, is applied to the cathode of tube V7A. The plate of V7A is grounded. The voltage developed across VAR ALARM control R91 is fed through a low-pass filter, which consists of resistor R92 and capacitor C48, to variable level alarm thyratron V16.

b. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

156. Variable Level Alarm Thyratron V16

(fig. 122)

Variable level alarm thyratron V16 uses a 5696 thyratron to energize variable alarm relay RY2.

a. The rectified signal from V7A is applied through protective resistor R94 to the grid of V16. A negative bias of —6 volts dc is obtained from the power supply through grid resistor R93. VAR ALARM control R91 is adjusted, with a preset signal input to V7A, to reduce the negative fixed bias and allow thyratron V16 to conduct and energize variable alarm relay RY2. Any decrease in signal input will cause the bias to cut off thyratron V16 and deenergize relay RY2.

b. Plate voltage of 115 volts ac is obtained from a secondary winding of transformer T4

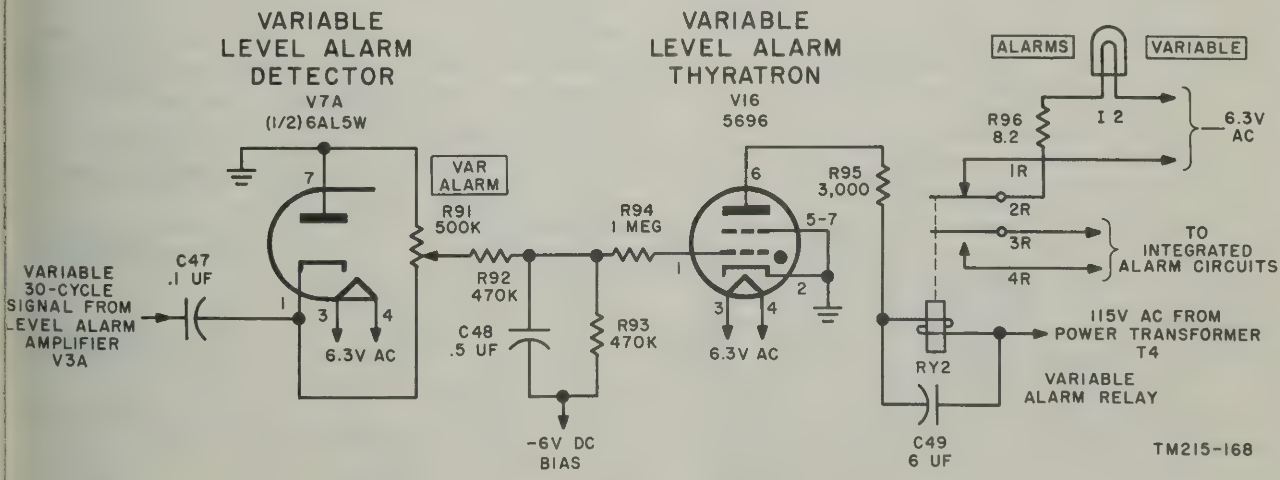


Figure 122. Variable level alarm detector V7A and variable level alarm thyratron V16, schematic diagram.

through current-limiting resistor R94 and the coil of variable alarm relay RY2. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

c. The coil of variable alarm relay RY2 is shunted by capacitor C49, which charges and holds relay RY2 energized between pulses of the rectified variable 30-cycle signal applied to the grid of V17. Contacts 1R and 2R of relay RY2, current-limiting resistor R96, and VAR ALARM indicator I 2 are in series across a 6.3-volt winding on the secondary of transformer T4. Contacts 3R and 4R of relay RY2 are in series with the 115 volts ac to the plate of reference fail-safe alarm thyratron V18. When relay RY2 deenergizes, the 115-volt circuit to tube V18 is opened and the 6.3-volt circuit is closed, causing VAR ALARM indicator I 2 to light.

157. Variable Fail-Safe Alarm Detector V7B

(fig. 123)

Variable fail-safe alarm detector V7B uses one-half of a 6AL5W twin diode to rectify the variable 30-cycle signal used to control variable fail-safe alarm thyratron V15.

a. The variable 30-cycle signal from output amplifier V11, coupled through capacitor C45, is applied to the cathode. The plate of V7B is grounded. The positive voltage developed across cathode resistor R84 is fed through a low-pass filter, which consists of resistor R85 and capacitor C46, to variable fail-safe alarm thyratron V15.

b. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

158. Variable Fail-Safe Alarm Thyraton V15

(fig. 123)

Variable fail-safe alarm thyratron V15 uses a 5696 tube to energize phase-alarm relay RY1.

a. The rectified signal from V7B is applied through protective resistor R87 to the grid of V15. A negative bias of —6 volts dc is obtained from the power supply through grid resistor R86; this bias will cut off thyratron V15 when the rectified signal output of detector V7B drops below the preset level.

b. Plate voltage of 115 volts ac is obtained from a secondary winding on transformer T4 through current-limiting resistor R88 and the coil of phase alarm relay RY1. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

c. The coil of phase alarm relay RY1 is shunted by capacitor C26, which charges and holds relay RY1 energized between pulses of the rectified variable 30-cycle signal applied to the grid of V15. The coil of relay RY1 is also shunted by contacts of COURSE RELAY meter M2 which short out the coil for a phase alarm. Contacts 1R and 2R of relay RY1, in series with resistor R41, are between ground and the output of the phase comparator circuit. Contacts 3R and 4R, when closed, supply 115 volts ac to COURSE RELAY meter M2 reset coil. Contacts 1L and 2L are closed when relay RY1 is deenergized and shorts the coil of course alarm relay RY4. Resistor R33 is a current-limiting resistor in the shorting circuit. Contacts 2L and 3L, which are

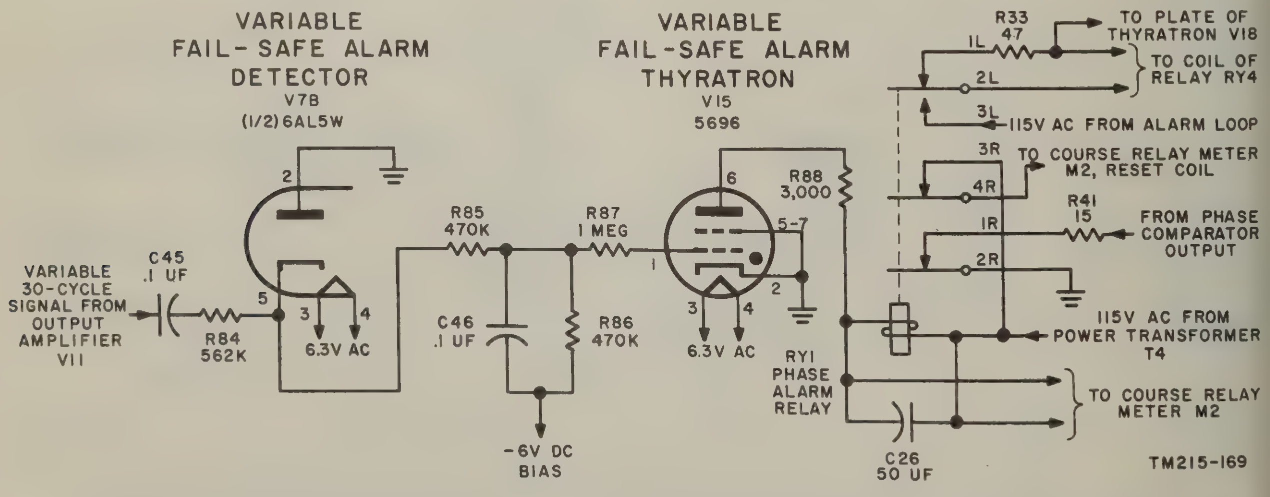


Figure 123. Variable fail-safe alarm detector V7B and variable fail-safe alarm thyratron V15, schematic diagram.

closed when relay RY1 is energized, apply 115 volts ac plate voltage to reference fail-safe alarm thyratron V18 through the coil of relay RY4.

159. Phase Comparator Circuit

(figs. 124 and 125)

The phase comparator circuit compares the phase difference between the variable 30-cycle signal from output amplifier V11 and the reference 30-cycle signal from output amplifier V12. When a phase difference occurs, a direct current is produced which deflects COURSE INDICATOR meter M1 and COURSE RELAY meter M2.

a. Transformers T1 and T2 are identical. The reference 30-cycle signal, from output amplifier V12, is developed in the center-tapped secondary of T1. The variable 30-cycle signal from output amplifier V11 is developed in the center-tapped secondary of transformer T2. The signal input to T1 and T2 is adjusted so that the amplitude of the current in one-half of the secondary of T1 very nearly equals the amplitude of the current in the full secondary of T2. Resistor R117 presents a constant load to T1. By connecting the full secondary of T2 between the center tap of T1 and ground, the output current of T2 (I_c) is effectively in series with the two currents (I_a and I_b) of T1.

b. Rectifiers CR1 and CR2 in each leg of the T1 secondary permit the current in each leg to flow in one direction only. Resistors R34 and R38 are current-limiting and load resistors for CR1 and CR2. Balance control R37 compensates for the manufacturing tolerances of CR1 and CR2, R34 and R38, and T1. The arm of balance control R37 is the dc output terminal of the phase comparator circuit, and C25 filters this output to prevent meter fluctuations.

c. The dc output of the phase comparator circuit is applied across the series meter circuit, which consists of isolation resistor R32, COURSE RELAY meter M2, COURSE INDICATOR meter M1, sensitivity control R39, and isolation resistor R40, to ground. COURSE INDICATOR meter M1 and COURSE RELAY meter M2 indicate the deviation between the reference and variable 30-cycle signals. COURSE RELAY meter M2 is equipped with contacts which cause an alarm by shorting the coil of phase alarm relay RY1 when deviation exceeds the preset level. When relay RY1 is deenergized, contacts 1R and 2R furnish a ground connection through resistor R41 to protect meters M1 and M2 from high current values. Deenergized contacts 3R and 4R of relay RY1 also apply 115 volts ac to the reset coil of COURSE RELAY meter M2. Sensitivity control R39 is a meter multiplier used to preset the amount of allowable phase deviation between reference and variable 30-cycle signals before the alarm system is activated.

d. Figure 125 is a simplified schematic diagram that contains simple vector diagrams of the currents in the phase comparator circuit. The phase comparator has been divided into two sections for discussion purposes. Three basic currents are supplied to the phase sensitive circuits: reference 30-cycle current (I_a), through one-half the secondary of T1; reference 30-cycle current (I_b), through the other half of T1 and 180° out of phase with, but equal to, current (I_a); and variable 30-cycle current (I_c), which is 90° out of phase with (I_a) and (I_b) and has an amplitude approximately equal to (I_a or I_b). The 90° phase shift between variable and reference 30-cycle signals was produced in phase-shift network S4/R72 (fig. 119).

e. The application of reference and variable 30-cycle signals to the phase comparator exactly 90° out of phase will produce the resultant current (I_{ac}) shown by vector diagram D. This vector is the vector sum of currents (I_a) and (I_c) circulating as shown in A. Diagram B combines currents (I_b) and (I_c) to produce resultant current (I_{bc}), shown vectorially in E. Therefore, currents (I_{ac}) and (I_{bc}) flow in opposite directions: alternating current through the capacitive reactance of capacitor C25 and direct current through meters M1 and M2. The resulting rectified dc output (I_o) from rectifiers CR1 and CR2 will be zero because currents (I_{ac}) and (I_{bc}) are equal but opposite through M1 and M2.

f. When the reference 30-cycle signal is shifted in phase with respect to the variable 30-cycle signal (C and H), the dc output to meters M1 and M2 will be of an amplitude and polarity determined by the comparative amplitudes of vectors (I_{ac}) and (I_{bc}). The resultant direct current (I_o) will assume the direction of the largest vector and deflect meters M1 and M2 an amount equal to the difference as shown in L.

g. A shift in the phase of the variable 30-cycle signal with respect to the reference 30-cycle sig-

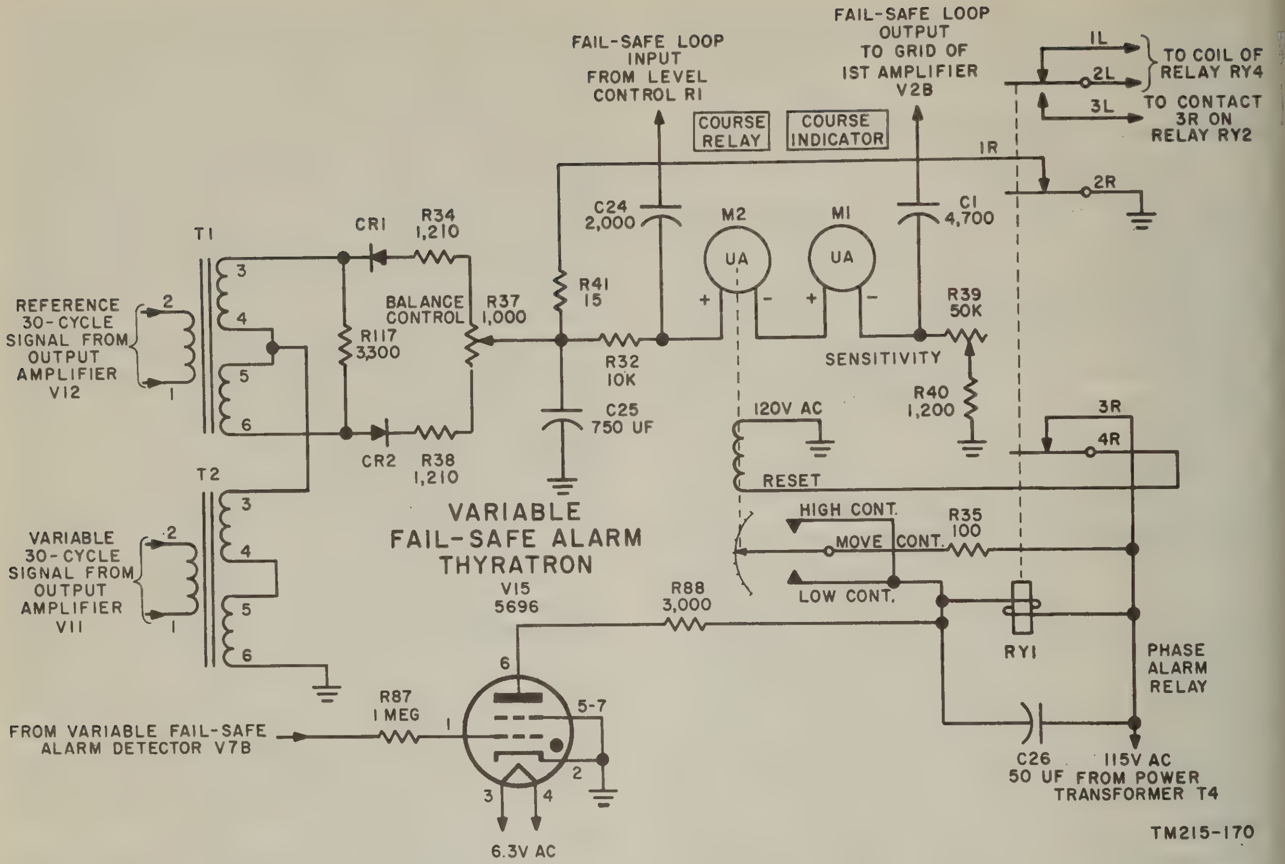

FAIL-SAFE LOOP INPUT FROM LEVEL CONTROL R1
FAIL-SAFE LOOP OUTPUT TO GRID OF 1ST AMPLIFIER V2B
COURSE RELAY
COURSE INDICATOR
1L
2L
3L
TO COIL OF RELAY RY4
TO CONTACT 3R ON RELAY RY2
1R
2R
T1
CR1
R34 1,210
C24 2,000
M2
M1
UA
UA
C1 4,700
REFERENCE 30-CYCLE SIGNAL FROM OUTPUT AMPLIFIER V12
2
3
4
5
6
1
BALANCE CONTROL
R37 1,000
R41 15
R117 3,300
R32 10K
R39 50K
SENSITIVITY
C25 750 UF
120V AC
R40 1,200
3R
4R
CR2
R38 1,210
T2
RESET
VARIABLE FAIL-SAFE ALARM THYRATRON
V15
5696
HIGH CONT.
MOVE
CONT.
R35 100
LOW CONT.
VARIABLE 30-CYCLE SIGNAL FROM OUTPUT AMPLIFIER V11
R88 3,000
RY1
PHASE ALARM RELAY
FROM VARIABLE FAIL-SAFE ALARM DETECTOR V7B
R87 1 MEG
5-7
2
3
4
6.3V AC
C26 50 UF
115V AC FROM POWER TRANSFORMER T4
TM215-170

Figure 124. Phase comparator circuit, schematic diagram.

nal results in vectors which are dominated by current (I_{ac}) (F, G, and L) or current (I_{bc}) (J, K, and L). The amplitude of the phase deviation will determine the degree of deflection indicated by meters M1 and M2. When failures occur in the carrier outputs of the antenna or in the monitor, an alarm will be triggered to provide complete fail-safe warning to the operator.

160. Integrated Alarm Circuit

(fig. 126)

The integrated alarm circuit will operate from any of the six alarms through a single pair of contacts which control the automatic transfer and/or shutdown functions.

a. Bias relay RY5 is energized by the —6-volt bias from power supply rectifier V10 to sense the proper functioning of the power supply. Phase alarm relay RY1, variable alarm relay RY2, and reference alarm relay RY3 have their coils in series with the 115-volt ac plate voltage supply to respective thyratrons V15, V16, and V17. During normal equipment operation, each alarm relay is energized by plate current flow. The 115-volt ac plate voltage for thyratron V18 is applied through one pair of contacts of each alarm relay (RY1, RY2, and RY3) and the coil of course alarm relay RY4 to reach the plate. Other than normal operation of any of the alarm circuits will open the appropriate alarm relay and deenergize course alarm relay RY4. Course alarm relay RY4 is also deenergized when reference fail-safe thyratron V18 is cut off or when course deviation exceeds the preset limits of COURSE RELAY meter M2. Excess course deviation closes the contacts of COURSE RELAY meter M2, shorting phase alarm relay RY1 coil. Whenever phase alarm relay RY1 deenergizes, contacts 1L/2L will short the coil of course alarm relay RY4 in addition to breaking the plate voltage supply to thyratron V18.

b. Contacts 3R and 4R on course alarm relay RY4 furnish a ground return for relay O 206 in the C–1738/FRN–20 and relay K601 in the C–1840/FRN–22. The opening of contacts 3R and 4R on course alarm relay RY4 will shut down the operating equipment and start the transfer cycle to the alternate equipment.

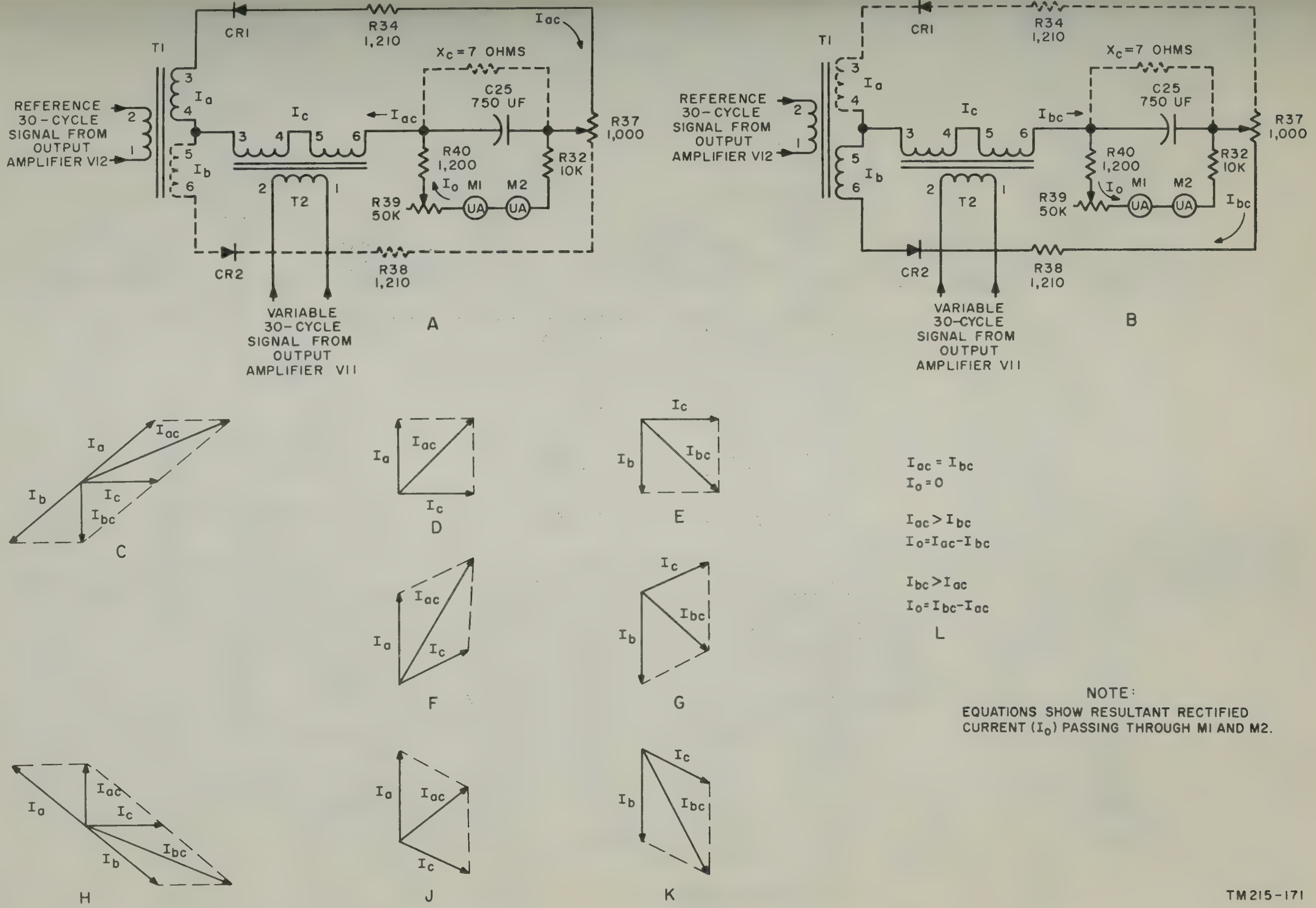


Figure 125. Phase comparator circuit, simplified schematic diagram.

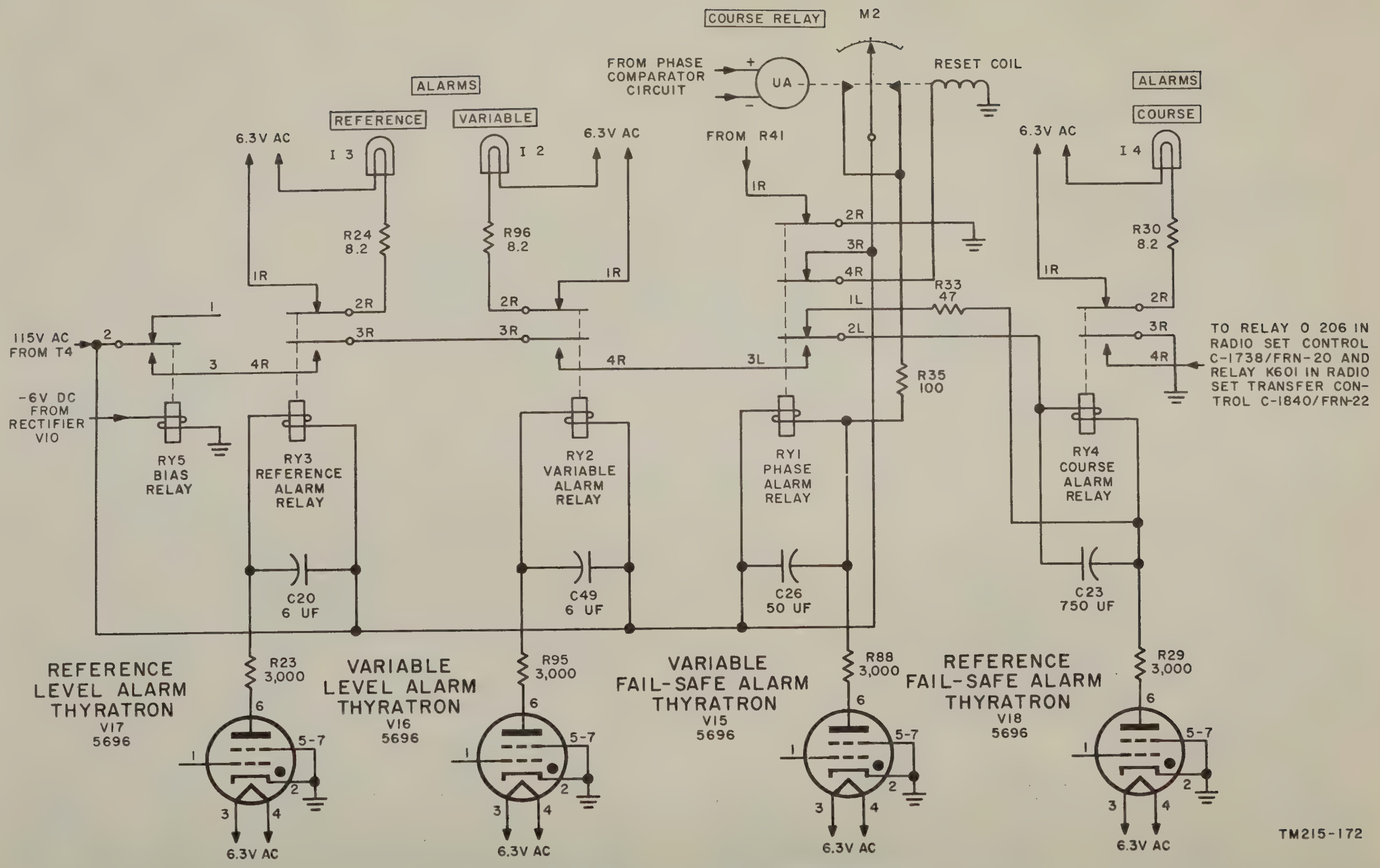

COURSE RELAY
M2
FROM PHASE COMPARATOR CIRCUIT
UA
+
-
RESET COIL
ALARMS
REFERENCE
VARIABLE
ALARMS
COURSE
6.3V AC
I 3
I 2
I 4
FROM R41
R24 8.2
R96 8.2
R30 8.2
IR
2R
3R
4R
IL
2L
3L
1
2
3
R33 47
R35 100
115V AC FROM T4
-6V DC FROM RECTIFIER V10
TO RELAY O 206 IN RADIO SET CONTROL C-1738/FRN-20 AND RELAY K601 IN RADIO SET TRANSFER CONTROL C-1840/FRN-22
RY5 BIAS RELAY
RY3 REFERENCE ALARM RELAY
RY2 VARIABLE ALARM RELAY
RY1 PHASE ALARM RELAY
RY4 COURSE ALARM RELAY
C20 6 UF
C49 6 UF
C26 50 UF
C23 750 UF
R23 3,000
R95 3,000
R88 3,000
R29 3,000
REFERENCE LEVEL ALARM THYRATRON V17 5696
VARIABLE LEVEL ALARM THYRATRON V16 5696
VARIABLE FAIL-SAFE ALARM THYRATRON V15 5696
REFERENCE FAIL-SAFE ALARM THYRATRON V18 5696
6
5-7
4
TM215-172

Figure 126. Integrated alarm circuit, schematic diagram.

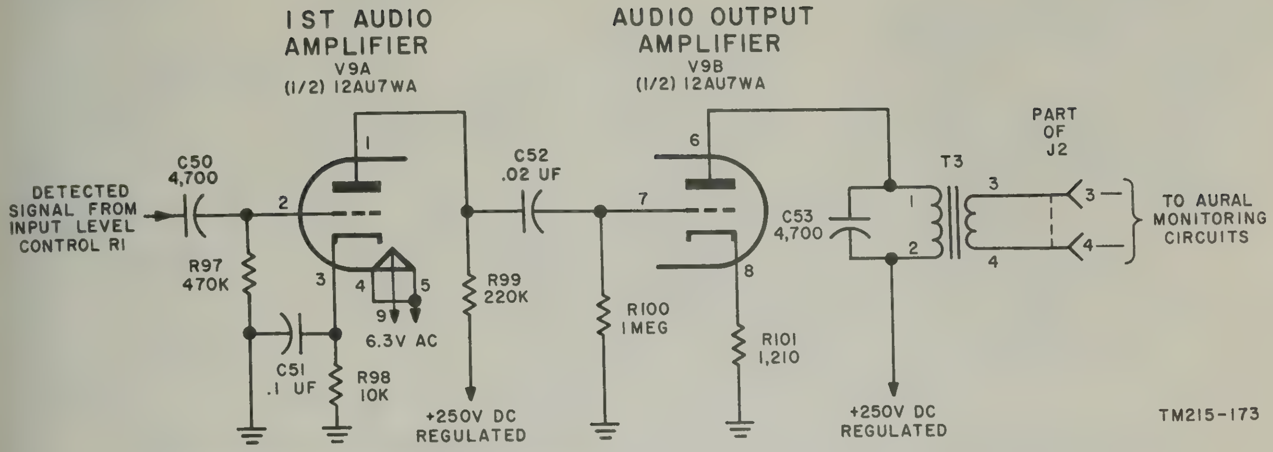


Figure 127. First audio amplifier V9A and audio output amplifier V9B, schematic diagram.

161. First Audio Amplifier V9A

(fig. 127)

First audio amplifier V9A uses one-half of a 12AU7WA twin triode to increase the detected signal from INPUT LEVEL control R1.

a. The signal from R1, coupled through capacitor C50, is applied across grid resistor R97. The output signal developed across plate load resistor R99 is coupled through capacitor C52 to audio output amplifier V9B.

b. Plate voltage for V9A is obtained from the power supply through plate load resistor R99. Self-bias is developed across cathode resistor R98, which is bypassed by capacitor C51.

c. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

162. Audio Output Amplifier V9B

(fig. 127)

Audio output amplifier V9B uses one-half of a 12AU7WA twin triode to increase the audio signal from V9A.

a. The input signal from tube V9A, coupled through capacitor C52, is applied across grid resistor R100. The output signal developed across output transformer T3 is coupled through receptacle J2 to the C–1738/FRN–20 aural monitoring circuits.

b. Plate voltage for V9B is obtained from the power supply through transformer T3. Capacitor C53 across the primary of transformer T3 reduces the noise level and prevents harmonic distortion. Self-bias is developed across cathode resistor R101.

163. Cathode Follower V13A

(fig. 128)

Cathode follower V13A is the first stage of the vacuum-tube voltmeter circuit and uses one-half of a 12AX7 twin triode to amplify the input signal.

a. The input signal from LEVEL switch S1, coupled through capacitor C54, is applied across grid resistor R102. The output signal is developed across cathode resistor R103 and coupled through capacitor C55 to amplifier V13B.

b. Plate voltage is obtained directly from the power supply.

164. Amplifier V13B

(fig. 128)

Amplifier V13B uses one-half of a 12AX7 twin triode to increase the signal from tube V13A.

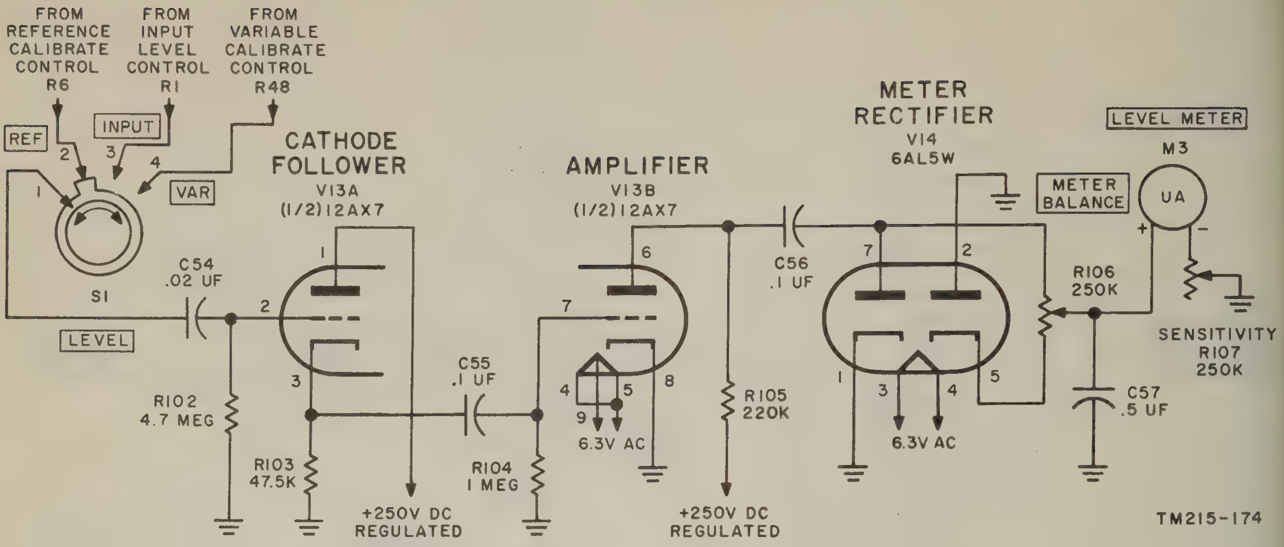


Figure 128. Cathode follower V13A, amplifier V13B, and meter rectifier V14, schematic diagram.

a. The signal from V13A, coupled through capacitor C55, is applied across grid resistor R104. The output signal developed across plate load resistor R105 is coupled through capacitor C56 to meter rectifier V14.

b. Plate voltage for V13B is obtained from the power supply through plate load resistor R105. Filament voltage for V13 is obtained from a 6.3-volt secondary winding on transformer T4.

165. Meter Rectifier V14

(fig. 128)

Meter rectifier V14 uses a 6AL5W twin diode to rectify the signal voltage from V13B and indicate the signal amplitude on LEVEL METER M3.

a. The signal from V13B, coupled through capacitor C56, is applied to the plate of the first section of V14 and through METER BALANCE control R106 to the cathode of the second section. Positive signal peaks are shunted to ground in the first section of V14 to permit only the negative peaks to be rectified. This charges capacitor C57. LEVEL METER M3 indicates the voltage across capacitor C57.

b. METER BALANCE control R106 balances out the contact potential of V14. With no signal input to the vtvm, the contact potential of the first section of V14 polarizes one end of METER BALANCE control R106 positive, and the second section of tube V14 polarizes the opposite end of control R106 negative. METER BALANCE control R106 is adjusted to the point where these contact potentials cancel and LEVEL METER M3 indicates zero.

c. Sensitivity control R107 calibrates LEVEL METER M3 to indicate 100 with an input signal of 0.2 volt ac to the vtvm.

d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

166. Rectifier V10

(fig. 129)

Rectifier V10 uses a 5R4WGA full-wave rectifier to develop +500 volts dc to feed series regulator V21 and V22.

a. The 115 volts ac from circuit breaker K1004 in the shelter is applied through receptacle J3, fuse F1, and switch S3 to the primary of transformer T4. Capacitors C58 and C59 are each connected between one side of the ac line and ground to balance out noise pulses. A center-tapped, high-voltage winding on the secondary of T4 furnishes 400 volts ac to the plates of V10.

b. The high-voltage center tap is connected to ground through bleeder resistor R116 paralleled by the coil of bias relay RY5 and filter capacitor C65. This provides —6 volts dc to bias the thyratrons.

c. The +500-volt dc output of V10 is filtered by a capacitor-input filter consisting of C60, C61, and L3. Filament voltage is supplied by a 5-volt secondary winding on transformer T4.

d. The secondary of T4 contains a 115-volt winding that furnishes the operating voltage for

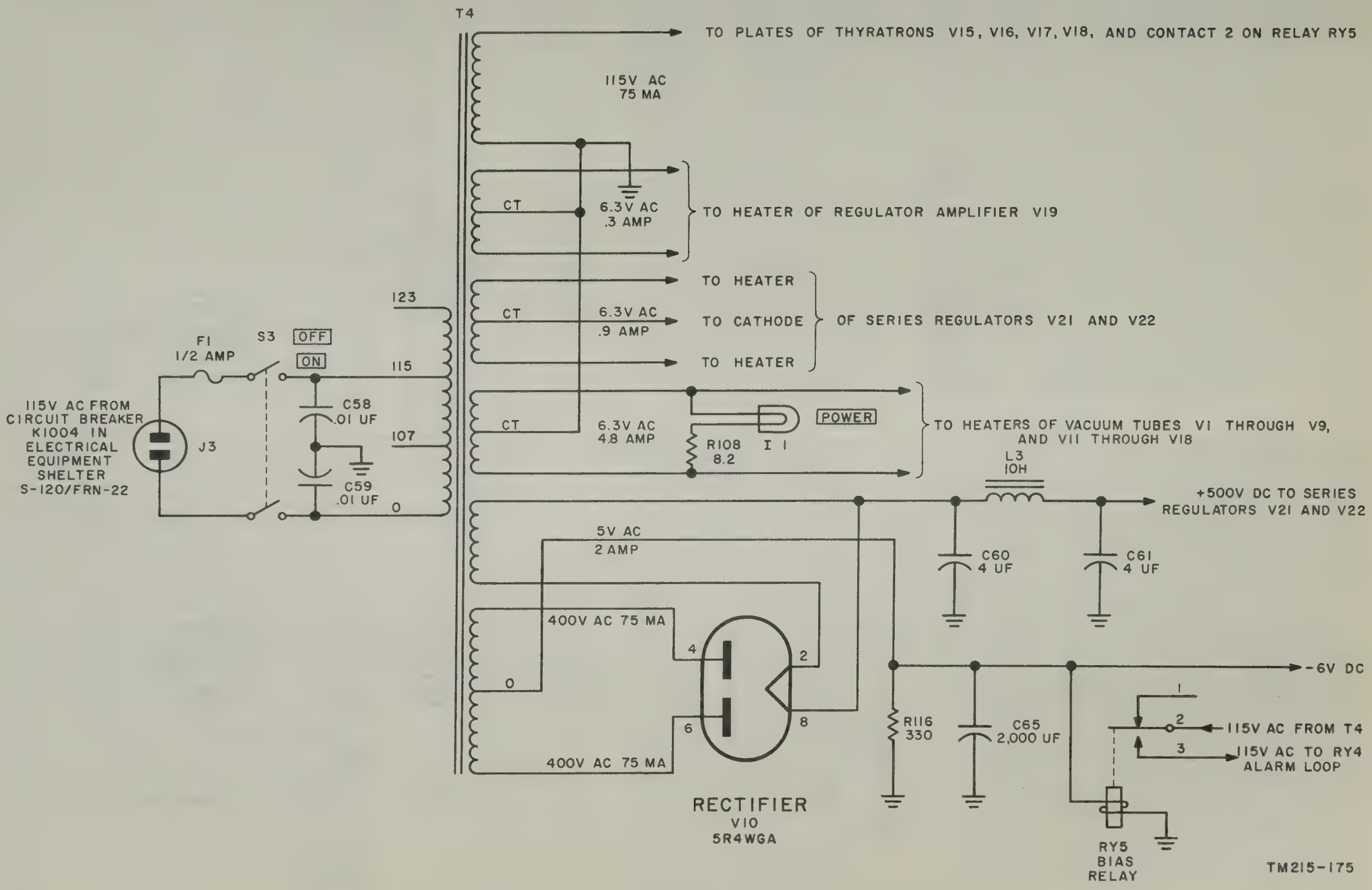


Figure 129. Rectifier V10, schematic diagram.

thyratrons V15 through V18. Transformer T4 also contains three 6.3-volt windings that furnish the filament voltage for all tubes in the monitor and the voltage to operate pilot and alarm lamps. One 6.3-volt winding, with the center tap grounded, furnishes filament voltage to regulator amplifier V19. The second 6.3-volt winding, with the center tap connected to the cathodes of series regulator tubes V21 and V22, furnishes the filament voltage for regulator tubes V21 and V22. The third 6.3-volt winding has the center tap grounded and furnishes filament voltage to all other tubes in the monitor and operating voltage for the alarm lamps. This winding also furnishes 6.3 volts through current-limiting resistor R108 to POWER on pilot lamp I1.

167. Series Regulator V21 and V22

(fig. 130)

Series regulator V21 and V22 uses two 6AQ5W pentodes connected as triodes to regulate the +500 volts dc from tube V10 and furnish +250 volts dc for the tubes in the monitor.

a. The +500 volts dc from V10 is parallel-connected to the plates and screen grids of V21 and V22 to provide sufficient current. The grids of V21 and V22 are connected through suppressor resistors R111 and R112 and are fed from regulator amplifier V19.

b. A voltage drop of 250 volts across V21 and V22 provides a +250-volt dc output at their cathodes. Additional filtering of the output voltage is provided by filter capacitor C64.

c. The voltage drop across V21 and V22 is controlled by the voltage on their grids which is received from regulator amplifier V19. When the output voltage is too high, the voltage on the grids of V21 and V22 will cause the voltage drop across these tubes to increase, thus regulating the output voltage at +250 volts.

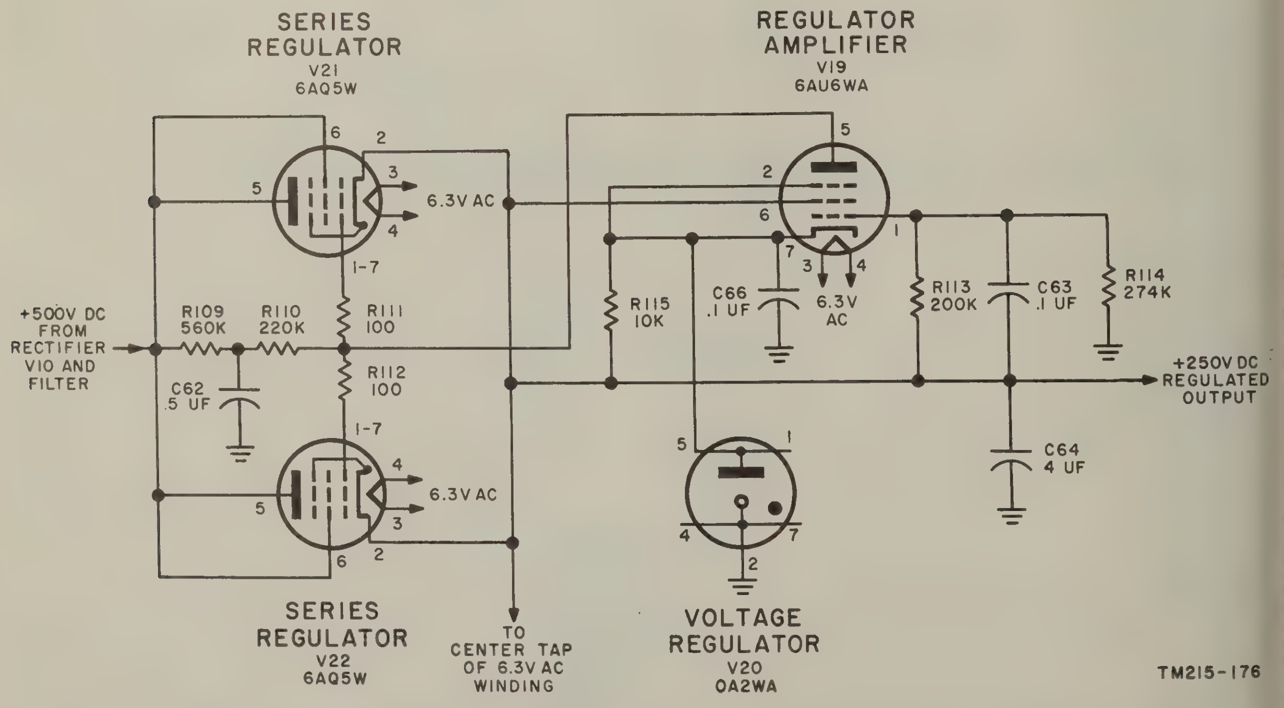
d. Filament voltage is obtained from a 6.3-volt secondary winding on transformer T4.

168. Regulator Amplifier V19 and Voltage Regulator V20

(fig. 130)

Regulator amplifier V19 uses a 6AU6WA pentode to increase and invert output voltage variations and feed a corrective signal to the grids of V21 and V22. Voltage regulator V20 uses an OA2WA tube to maintain the cathode of V19 at a constant dc potential.

a. The +250-volt dc output of V20 and V21 is applied to the grid of V19 through voltage dividing resistors R113 and R114. Capacitor



SERIES REGULATOR V21 6AQ5W
REGULATOR AMPLIFIER V19 6AU6WA
6
2
3
5
4
6.3V AC
1-7
5
2
6
1
7
3
4
+500V DC FROM RECTIFIER V10 AND FILTER
R109 560K
R110 220K
R111 100
R112 100
C62 .5 UF
R115 10K
C66 .1 UF
6.3V AC
R113 200K
C63 .1 UF
R114 274K
+250V DC REGULATED OUTPUT
C64 4 UF
1-7
4
6.3V AC
5
3
6
2
5
1
4
7
2
SERIES REGULATOR V22 6AQ5W
TO CENTER TAP OF 6.3V AC WINDING
VOLTAGE REGULATOR V20 OA2WA
TM215-176

Figure 130. Regulator amplifier V19, voltage regulator V20, and series regulator V21 and V22, schematic diagram.

C63 shunts resistor R113 to improve regulation by absorbing short surges. The output of V19, developed across plate load resistor R110, is applied to the grids of V21 and V22.

b. Plate voltage for V19 is obtained from the +500-volt dc output of V10 through series dropping resistor R109 and plate load resistor R110. The voltage fluctuations amplified by V19 are filtered by capacitor C62. Screen voltage for V19 is obtained from the +250-volt output. Capacitor C66 is a cathode bypass capacitor.

c. Voltage regulator V20 is connected between the cathode of V19 and ground. Voltage to ionize tube V20 is obtained from the +250-volt dc regulated output through resistor R115.

d. Filament voltage for V19 is obtained from a 6.3-volt secondary winding on transformer T4.

Section XV. THEORY OF POWER SUPPLY PP–1415/FRN–22

169. General

Power Supply PP–1415/FRN–22 provides —12 volts dc to operate the control and simplex circuits. For complete circuit details, refer to the schematic diagram (fig. 131).

170. Rectifier CR1201

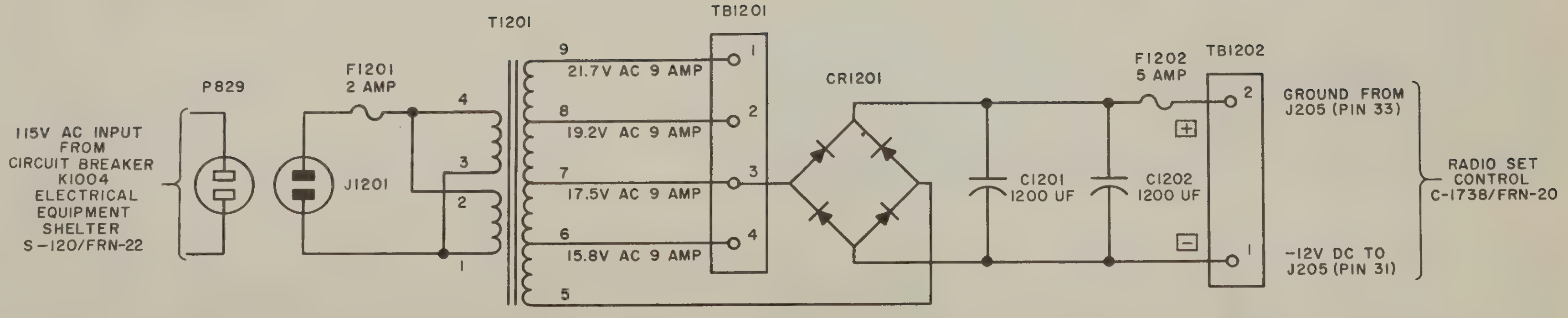
(fig. 131)

Rectifier CR1201 is a full-wave, single-phase, dry-disk, copper-sulfide bridge rectifier that rectifies ac voltage and provides a —12-volt dc output.

a. The 115 volts ac from circuit breaker K1004 in the shelter is fed through receptacle J1201 and fuse F1201 to the primary winding of stepdown transformer T1201. The secondary winding of transformer T1201 has four taps. Each of the taps is connected to a terminal on terminal board TB1201.

b. The input to rectifier CR1201 may be connected to any of the four terminals on terminal board TB1201. The proper terminal is determined by the load on the —12-volt dc supply.

c. The output voltage is filtered by capacitors C1201 and C1202 and connected through fuse F1202 and terminal board TB1202 to the C–1738/FRN–20. The positive lead is grounded at the C–1738/FRN–20.



NOTES

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ☐ INDICATES EQUIPMENT MARKING.

TM215-178

Figure 131. Power Supply PP-1415/FRN-22, schematic diagram.

171. General

The remote control unit controls the operation of the omnirange set from a remote location and monitors the operation of the omnirange set. The remote control unit also controls the facilities used for voice modulation. For complete circuit details, refer to the schematic diagram (fig. 286).

172. Dial and Audio Signal Circuits

(fig. 132)

The dial circuits are used to turn on or off the omnirange set and to place the C-1840/FRN-22 in standby condition. The audio circuits form an intercom between the local and remote locations, provide aural monitoring of the audio output signal from the monitor, and provide a means to voice modulate the RF carrier.

a. The 115-volt ac input at receptacle J503 is applied through fuse F501 to the primary of transformer T502. A 115-volt winding on the secondary of T502 furnishes 115 volts ac to dial I 501. This voltage is interrupted by I 501 and provides pulses corresponding to the number dialed through deenergized contacts of press-to-talk relay O 501, transformer T501, and the telephone line.

b. The audio output signal from the monitor and the intercom signal are carried from the omnirange site to terminal board E501 in the remote control cabinet (fig. 16) over the telephone line. These signals are fed from terminal board E501 through transformer T501 to receptacle J501. Handset HS1 is connected to receptacle J501 to receive these signals.

c. The audio signal from microphone MK1 is applied through receptacle J502 and terminal board E501 to the AM-1247/FRN-20. The audio signal from the AM-1247/FRN-20 is applied through terminal 6 on terminal board E501 to contact 4 and 5 of dial I 501 to transformer T501, through contacts 2 and 1L of press-to-talk relay O 501 and over the telephone line to the omnirange site. Press-to-talk relay O 501 is energized by 6.3 volts ac from a winding on transformer T502. The ground return for the O 501 coil is through receptacle J502 and the press-to-talk switch on microphone MK1.

173. Indicator Circuits

(fig. 133)

The indicator circuits provide a visual and an audible indication as to the status of the transmitting equipment by two indicator lamps and a buzzer.

a. Buzzer I 502 and indicator lamps I 503 and and I 504 are operated on 6.3 volts ac received from transformer T502. The operation of these indicators is controlled by connecting or removing the ground return to each by the action of relay O 502.

b. ALARM SELECTOR switch S501 should be set to the down position when the transmitting equipment is dialed off. This action will silence buzzer I 502 by removing the ground return.

c. When the warmup condition is dialed for either transmitting equipment, +12 volts dc is applied through the telephone line to transformer T501. The +12 volts is then fed from the center tap of T501 through contacts 2 and 3 of relay O 501, rectifier CR502, and contacts 8 and 9 of switch S501 to the coil of relay O 502. Relay O 502 energizes and places a ground return on indicator lamps I 503 and I 504 and buzzer I 502. Switch S501 must be in the center position to silence buzzer I 502. Amber indicator lamp I 503 indicates when the transmitter is on.

d. When omnirange operation is dialed for either transmitting equipment, and sufficient time is allowed for the monitor to become stabilized, -12 volts dc is applied to T501 from the telephone line. The -12 volts is applied through contacts 2C and 3C of relay O 501. Switch S501 should be placed in the up position. This position applies 6.3 volts from transformer T502 to green indicator lamp I 504, which is grounded through the contacts of relay O 502. When green VOR ON lamp I 504 is on, the omnirange set is functioning properly.

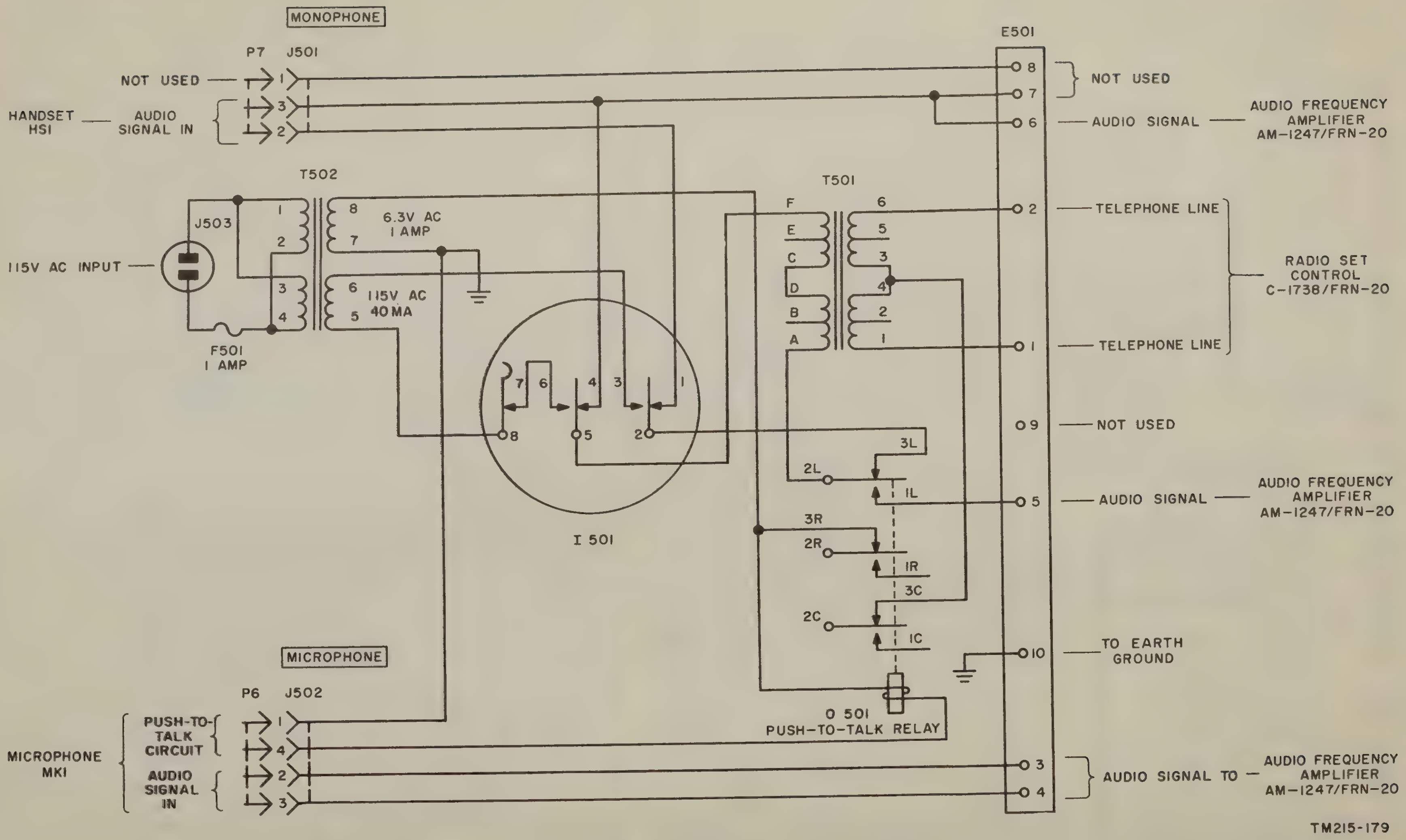


Figure 132. Dial and audio signal circuits, schematic diagram.

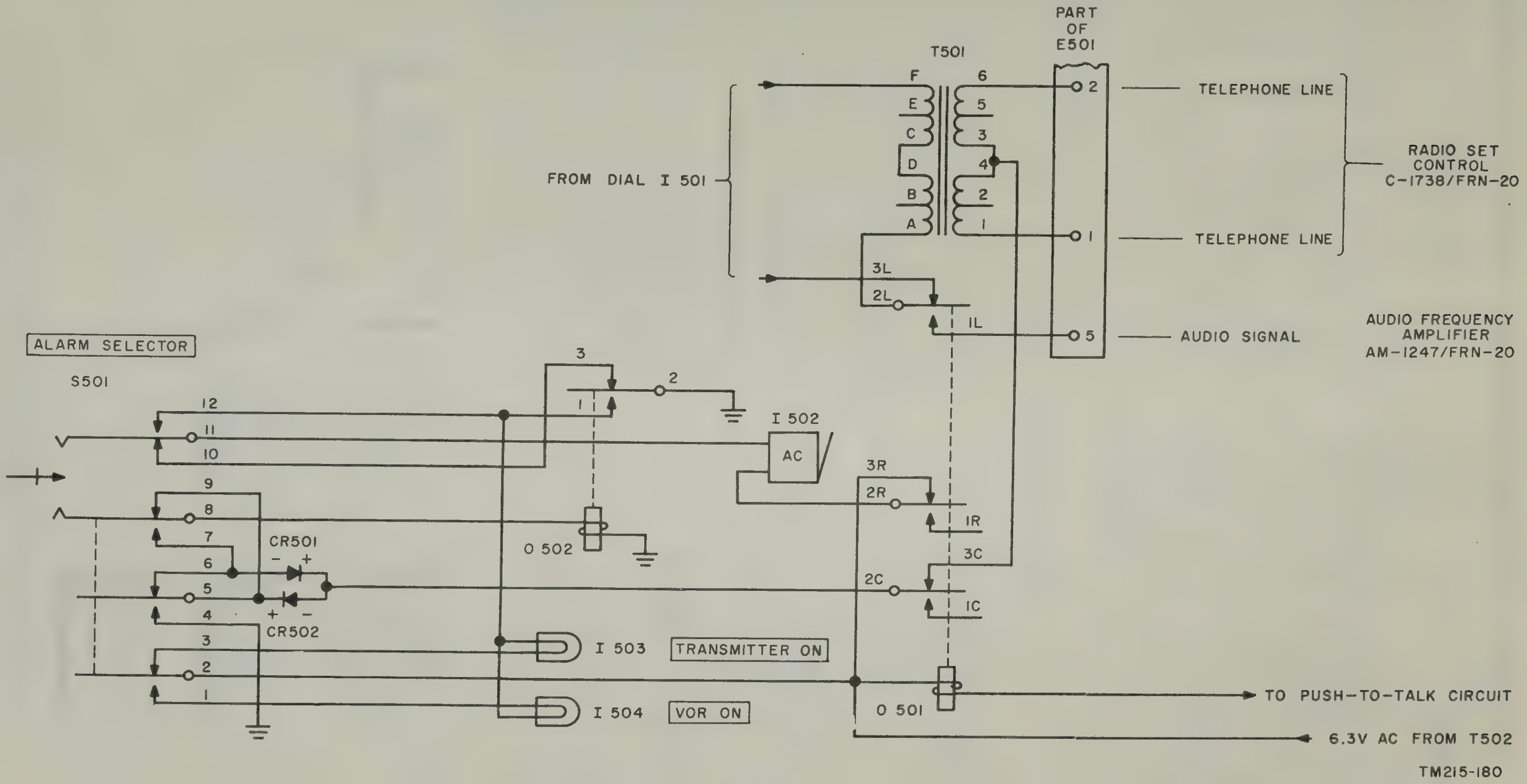


Figure 133. Indicator circuits, schematic diagram.

Section XVII. THEORY OF AUDIO FREQUENCY AMPLIFIER AM–1247/FRN–20

174. Block Diagram

(fig. 134)

Audio Frequency Amplifier AM–1247/FRN–20 receives from the remote control unit the audio signal produced by microphone MK1 and amplifies it to provide a constant output level of 0 db. The signal path is shown in the block diagram (fig. 134) and is discussed in *a* through *f* below. For complete circuit details, refer to the overall schematic diagram (fig. 287).

a. The audio signal is coupled to input amplifier V1 and V2 where it is amplified and coupled to second amplifier V3.

b. Second amplifier V3 further amplifies the signal and feeds it to output amplifier V4 and agc amplifier V6.

c. Output amplifier V4 increases the signal strength to provide a 0-db output level.

d. Agc amplifier V6 increases the signal strength enough to overcome the threshold bias on agc detector V5.

e. Agc detector V5 rectifies the signal and develops the agc voltage applied to the grids of input amplifier V1 and V2.

f. Dc operating voltages are developed by rectifier V7.

175. Input Amplifier V1 and V2

(fig. 135)

Input amplifier V1 and V2 uses two 6SA7Y heptodes connected as a push-pull amplifier to amplify the audio signal and provide speech compression above a preset level.

a. The signal from the remote control unit is applied through receptacle J1 and INPUT LEVEL control R1 to the primary of input transformer T1. The center-tapped secondary of T1 feeds the audio signal to the injection grids of V1 and V2. The output signal is developed in transformer T2 and coupled to second amplifier V3.

b. Plate voltage for V1 and V2 is obtained from rectifier V7 through series resistor R5 and shunt feed resistors R6 and R7. Capacitor C2 isolates the primary of T2 from the dc plate. Audio signals are isolated from the B+ supply by capacitor C1 and resistor R5. A bleeder, consisting of resistors R2, R3, and R4, is connected between rectifier V7 output and ground. Screen voltage for V1 and V2 is taken from the junction of resistors R3 and R4. The cathodes of V1 and V2 are connected to the junction of R2 and R3 to obtain fixed bias. An agc bias is applied to the control grids of V1 and V2 whenever the signal level rises above the preset level.

c. Filament voltage is obtained from the 6.3-volt center-tapped winding on transformer T5.

176. Second Amplifier V3

(fig. 136)

Second amplifier V3 uses a 6SN7WGTA twin triode connected as a push-pull amplifier to further amplify the audio signal.

a. The signal from V1 and V2, coupled through transformer T2, is applied to the push-pull grids of V3. The output signal, developed across plate

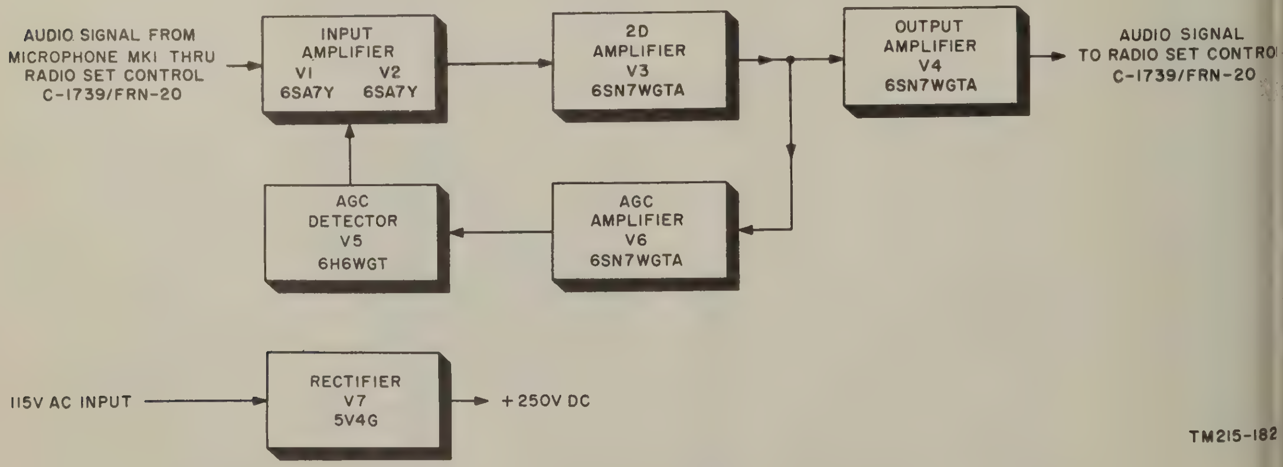


Figure 134. Audio Frequency Amplifier AM–1247/FRN–20, block diagram.

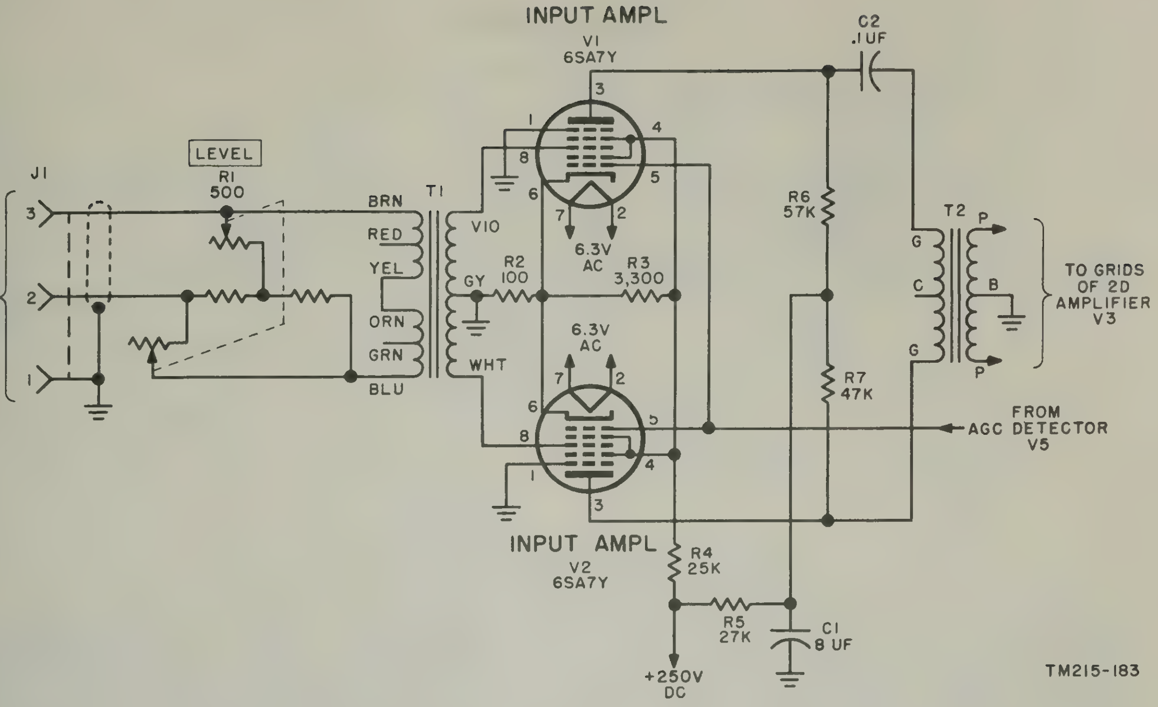


Figure 135. Input amplifier V1 and V2, schematic diagram.

load resistors R9 and R10, is coupled through capacitors C3 and C4 to output amplifier V4 and agc amplifier V6.

b. Plate voltage is obtained from rectifier V7 through plate load resistors R9 and R10. Self-bias is developed across cathode resistor R8.

c. Filament voltage for V3 is obtained from the 6.3-volt center-tapped winding on transformer T5.

177. Output Amplifier V4

(fig. 137)

Output amplifier V4 uses a 6SN7WGTA twin triode connected as a push-pull amplifier to amplify the audio signal to the preset level.

a. The input signal from V3, coupled through capacitors C3 and C4, is applied across grid resistors R11 and R12 to the push-pull grids of V4. The output signal developed in transformer

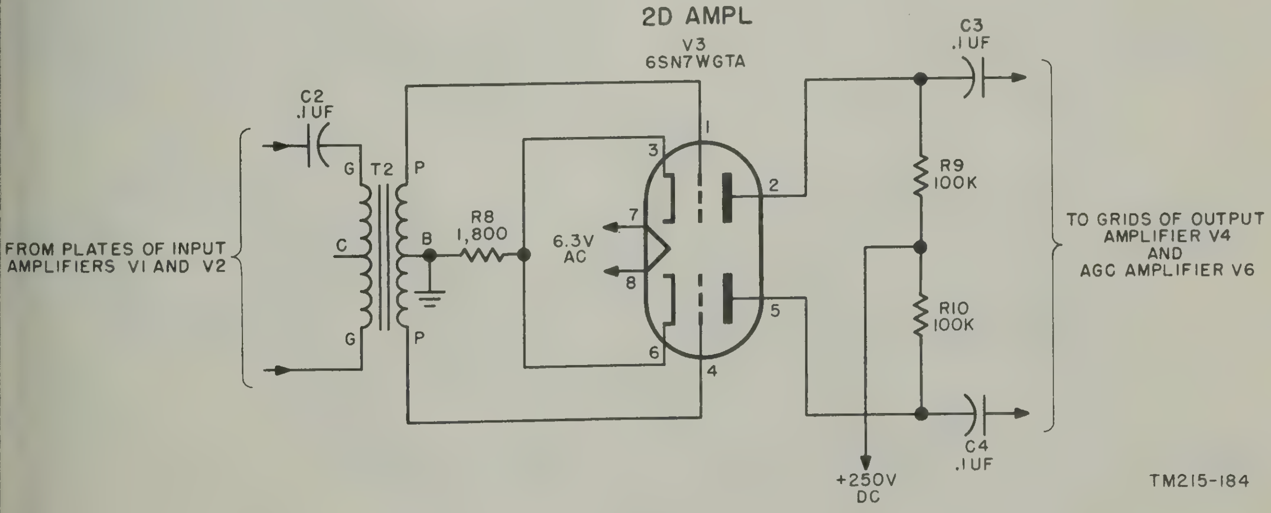


Figure 136. Second amplifier V3, schematic diagram.

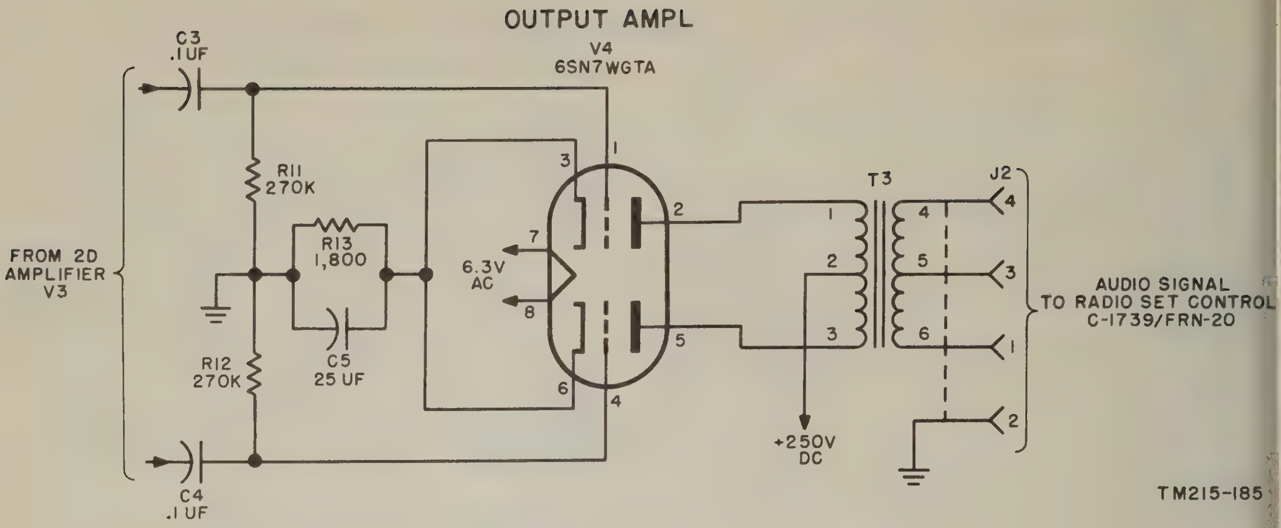


Figure 137. Output amplifier V4, schematic diagram.

T3 is applied through receptacle J2 to the remote control unit.

b. Plate voltage is obtained from rectifier V7 through the center tap of T3. Self-bias is developed across cathode resistor R13, which is bypassed by capacitor C5.

c. Filament voltage is obtained from a 6.3-volt center-tapped winding on transformer T5.

178. Agc Amplifier V6

(fig. 138)

Agc amplifier V6 uses a 6SN7WGTA twin triode connected as a push-pull amplifier to amplify the audio signal enough to overcome the threshold bias on agc detector V5.

a. The input signal, coupled through capacitors C3 and C4, is applied to the push-pull grids of tube V6. The output signal developed in transformer T4 is coupled to the plates of agc detector V5.

b. Plate voltage is obtained from rectifier V7 through the center tap of transformer T4. Self-bias is developed across cathode resistor R20.

c. Filament voltage is obtained from the 6.3-volt center-tapped winding on transformer T5.

179. Agc Detector V5

(fig. 139)

Agc detector V5 uses a 6H6WGT twin diode as a full-wave rectifier to adjust and filter the audio signal and provide an agc bias.

a. The signal, coupled through transformer T4, is applied to the plates of V5. When the positive peaks of the audio signal increase enough to overcome the positive dc bias applied to the cathodes of V5, the tube will conduct. The dc output voltage of V5, developed across plate load resistors R18 and R19, is filtered by resistor R17 and capacitor C6 and applied to the control grids of input amplifier V1 and V2.

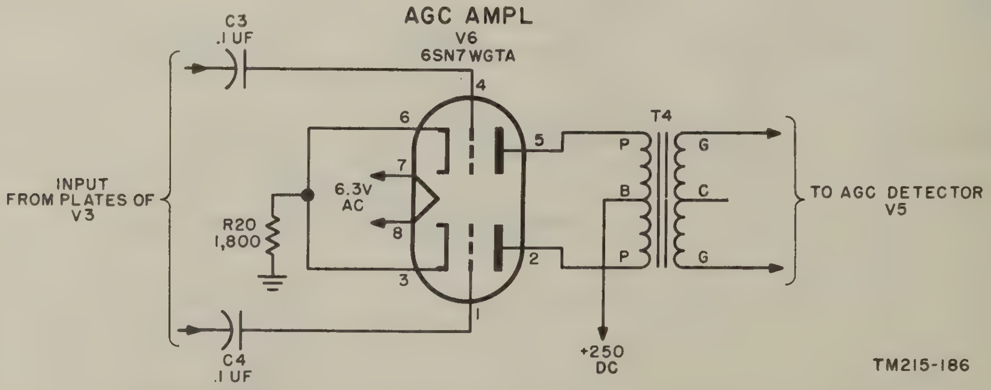


Figure 138. Agc amplifier V6, schematic diagram.

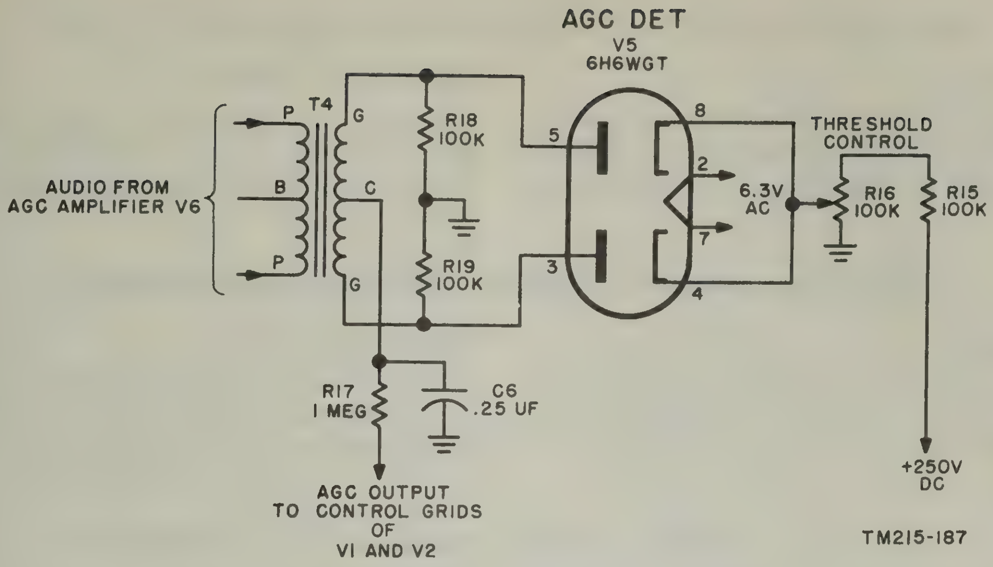


Figure 139. Agc detector V5, schematic diagram.

b. The positive dc bias applied to the cathodes is obtained from the arm of threshold control R16. Threshold control R16 is connected in series with bleeder resistor R15 across the power supply.

c. Filament voltage is obtained from the 6.3-volt center-tapped winding on transformer T5.

180. Rectifier V7

(fig. 140)

Rectifier V7 uses a 5V4G full-wave rectifier to develop +250 volts dc for the plate and screen requirements of the tubes in the AM–1247/FRN–20.

a. The 115 volts ac is applied through receptacle J3 and fuse F1 to the primary of transformer T5. A center-tapped high-voltage winding on the secondary of T5 furnishes 350 volts ac to the plates of V7.

b. The output of V7 is filtered by a choke input filter consisting of chokes L1 and L2 and three-section capacitor C7. Bleeder resistor R15 and threshold control R16 furnish the bleeder current and provide a discharge path for capacitor C7. Threshold control R16 also provides a positive potential to control the operation of tube V5. Filament voltage is supplied by a 5-volt winding on transformer T5.

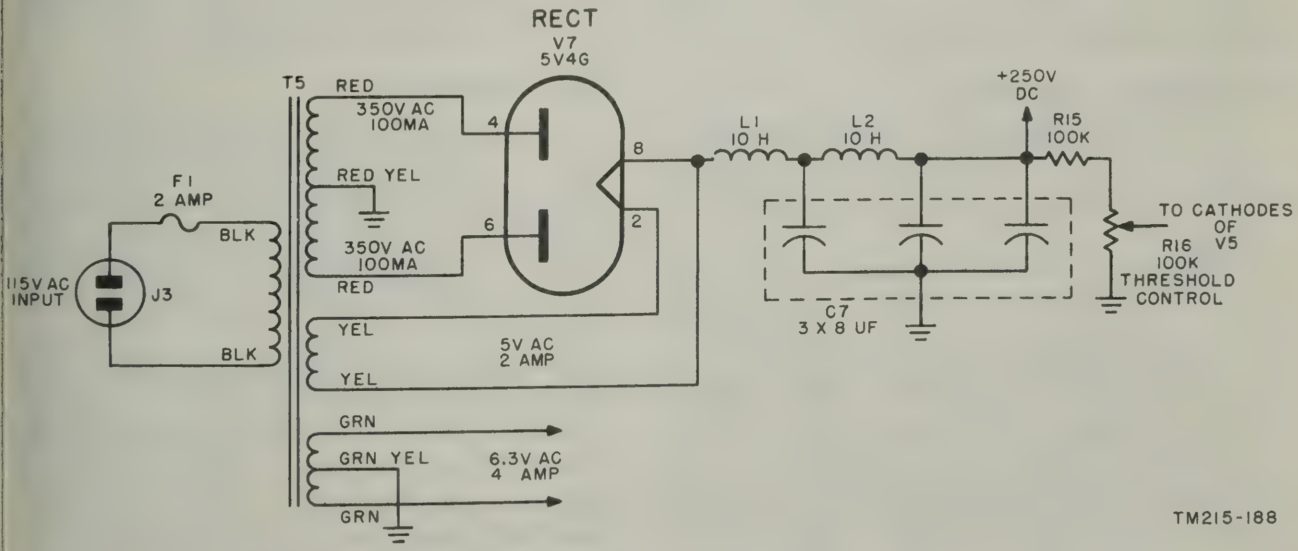


Figure 140. Rectifier V7, schematic diagram.

Section XVIII. THEORY OF RADIO SET CONTROL C–1738/FRN–20

181. General

Radio Set Control C–1738/FRN–20, working in conjunction with other units, provides facilities to control the operation of the omnirange set.

182. Circuit Details

Complete circuit details for the C–1738/FRN–20 are discussed in the interunit theory sections. The overall schematic diagram is shown in figure 288.

Section XIX. THEORY OF RELAY ASSEMBLY RE–248/FRN–22

183. General

Relay Assembly RE–248/FRN–22, working in conjunction with other units, provides facilities to control the operation of the omnirange set.

184. Circuit Details

Complete circuit details for the RE–248/FRN–22 are discussed in the interunit theory sections. The overall schematic diagram of the auxiliary control unit is shown in figure 289.

Section XX. THEORY OF RELAY ASSEMBLY RE–247/FRN–22

185. General

Relay Assembly RE–247/FRN–22 provides facilities to control the ac power to the units of the omnirange set.

186. Circuit Details

Complete circuit details for the RE–247/FRN–22 are discussed in the interunit theory sections. The overall schematic diagram of the power control unit is shown in figure 290.

Section XXI. THEORY OF RADIO SET TRANSFER CONTROL C–1840/FRN–22

187. General

Radio Set Transfer Control C–1840/FRN–22 automatically dials the standby transmitting equipment when actuated by an alarm from the monitor. The C–1840/FRN–22 will dial first one equipment, then the other until the monitor receives a normal signal or until each transmitting equipment has been tried three times. The seventh cycle of the C–1840/FRN–22 will turn off both transmitting equipments.

188. Standby Condition

(fig. 141, contained in separate envelope)

Number five on either dial of the omnirange set must be dialed to place the C–1840/FRN–22 in standby.

a. When number five is dialed, —12 volts from the contacts of slow release relay O 201 in the C–1738/FRN–20 is applied through pin 11 of receptacle J602 and the contacts of minor switch K605D to the coil of relay K601. Relay K601 will energize if the monitor has received a normal signal and closed course alarm relay RY4, which furnishes the ground return to relay K601. A voltage of —12 volts is also applied from the contact arm, in position number five, of minor switch K201 in the C–1738/FRN–20 through pin 1 of receptacle J602 to the open contacts of relay K601.

b. The —12-volt control voltage to the dialing circuits is fed through contacts of relays K602 and K603 to disable the dials during the transfer cycle. This circuit also provides holding voltage for relay K601. The keyed tone is applied through resistor R601 and contacts of relay K604 for muting during a transfer cycle.

189. Operation

(fig. 141, contained in separate envelope)

The transfer cycle of the C–1840/FRN–22 is started when the monitor detects an abnormal signal and produces an alarm. The first cycle of the C–1840/FRN–22 always dials equipment No. 1 regardless of which equipment was in operation.

a. An alarm from the monitor causes relay K601 to deenergize. Twelve volts is then fed through contacts 1R and 2R of relay K601, contacts 1L and 2L of relay K603, and contacts of minor switch K605C to the coil of relay K602. Relay K602 energizes and opens the contacts to disable the manual dial, closes the 115-volt ac circuit to the motor of sequence timer S601, and closes the —12-volt holding circuit for relay K602.

b. Sequence timer S601 starts operating from 115 volts ac through receptacle J601 and fuse F601 when relay K602 closes. The cam speed of the sequence timer is one-quarter rpm on 60-cycle power and ⅕ rpm on 50-cycle power. The following time elements are based on a cam speed of one-quarter rpm.

(1) Cam A actuates switch S601A 6⅔ seconds after the motor starts. Switch S601A is in the motor circuit and allows the sequence timer to complete a cycle regardless of relay action.

(2) Cam B actuates switch S601B 6⅔ seconds after cam A operates. Switch S601B feeds —12 volts through contacts 2 and 3 of S601B and contacts 1 and 2 of switch S601C to the contact arm of minor switch K605A. The minor switch contact arm supplies —12 volts through receptacle J601 to either equipment No. 1 or equipment No. 2 warmup relays, depending on the position of the contact arm.

(3) Cam C actuates switch S601C 66⅔ seconds after cam B operates. This time element allows enough time for the tube filaments to warm up. Switch S601C removes the —12 volts from the contact arm of minor switch K605A and applies —12 volts to the coil of relay K603. Relay K603 supplies —12 volts to the coil of relay K601 so it can energize as soon as the monitor clears the alarm. Switch S601C also applies —12 volts through contacts 1 and 2 of switch S601D to the step coil of K605D. This moves the contact arms of minor switch K605 to the next position.

(4) Cam D actuates switch S601D 6⅔ seconds after cam C operates. Switch S601D removes the —12 volts from the step coil of K605D and applies —12 volts to the coil of relay K604. Relay K604 energizes, feeding —12 volts through contacts 2R and 3R to the contact arm of minor switch K605B, and receptacle J602 to either equipment No. 1 or equipment No. 2 omni relays (O 205 and O 302, respectively, fig. 155), depending on the position of the contact arm on K605B.

(5) Cam B returns switch S601B to standby position 133⅓ seconds after cam D operates. This allows enough time for transmitting equipment to stabilize and the monitor to clear the alarm. Switch S601B deenergizes relays K602, K603, and K604. Cam C returns switch S601C to standby position 6⅔ seconds after cam B returns to the home position. Cam D returns switch S601D to standby position 6⅔ seconds after cam C returns to the home position. Cam A returns switch S601A to standby position, turning off the motor 13⅓ seconds after cam D returns to the home position.

c. Resistor R602 and capacitor C601 provide damping for the step coil of minor switch K605.

d. Thermal relay K606 resets minor switch K605 in the event of a power failure. Without this reset feature, six power failures or a combination of alarms and power failures would move minor switch K605 to the station shutdown position. The 115 volts ac to the motor of sequence timer S601 also heats thermal relay K606. The normally closed contacts of K606 remain open during normal operation of the transmitting set. A power failure allows the heaters to cool and the contacts of K606 to close. When the power is returned, —12 volts is applied through the closed contacts of K606 to the release coil of minor switch K605. The release coil of K605 returns the contact arms to their home position.

Section XXII. THEORY OF VOLTAGE REGULATOR CN–358/FRN–22

190. Block Diagram

(fig. 142)

Voltage Regulator CN–358/FRN–22 provides a stable source of ac power for operation of components in the omnirange set. The voltage path is shown in the block diagram and is discussed in *a* through *f* below. For complete circuit details, refer to the overall schematic diagram (fig. 291).

a. The input voltage is applied to buck-boost transformer T4 and powerstat transformer T3.

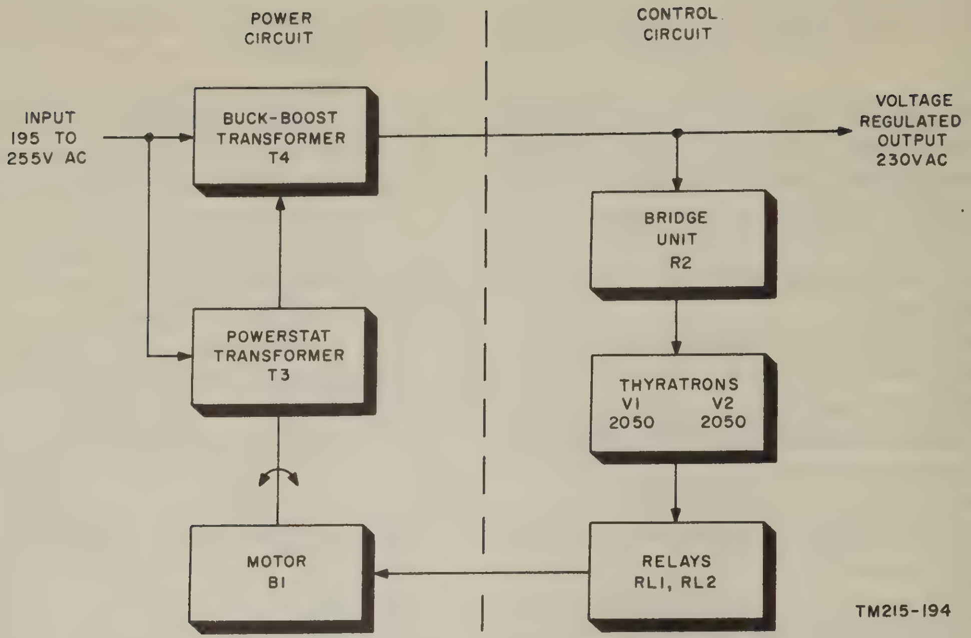


Figure 142. Voltage Regulator CN–358/FRN–22, block diagram.

A portion of the output voltage is fed through the control circuits before being applied to the output.

b. Bridge unit R2 receives a portion of the output voltage. If the output voltage is either above or below the preset value of 230 volts ac, the bridge unit feeds a control voltage to thyratrons V1 and V2.

c. The polarity of the voltage from the bridge unit determines which thyratron will conduct.

d. Relays RL1 and RL2 are energized by the current from their respective thyratrons and close the ac circuit to motor B1.

e. Motor B1 rotates in either direction, depending on which relay closes. Motor B1 positions a brush assembly on powerstat transformer T3.

f. The brush assembly of powerstat transformer T3 feeds a voltage to buck-boost transformer T4 that either adds to or subtracts from the input voltage to regulate the output.

191. Power Circuit

(fig. 143)

The power circuit consists of motor-driven variable transformer T3, buck-boost transformer T4, and overload circuit breaker K1.

a. An ac voltage of 195 to 225 volts is applied to the voltage regulator to obtain a regulated 230-volt ac output. The input voltage is applied through circuit breaker K1 to transformer T3. One side of the line is connected through the secondary of transformer T4 to output terminal 4 on terminal board TB1. The other side of the line is connected straight through the voltage regulator to terminal 3 output terminal board TB1.

b. A change in output voltage causes a relay in the voltage regulator control circuit to close the 115-volt circuit from a tap on transformer T3 to motor B1. This causes motor B1 to rotate in the required direction, driving the brush assembly of transformer T3. Transformer T3 then delivers a voltage of proper magnitude and phase through the operating coil of circuit breaker K1 to the primary of buck-boost transformer T4 to correct the deviation in the output voltage. The output voltage of the regulator is indicated on voltmeter M1.

c. Limit switches S1 and S2 open the ac circuit to the motor at the end of rotation to prevent damage to the powerstat assembly. Resistor R1 and capacitor C9 form a phase-splitting network for motor B1. Fuses F2, F3, and F5 protect motor B1 against overloads. Fuse F1 is a meter protection fuse.

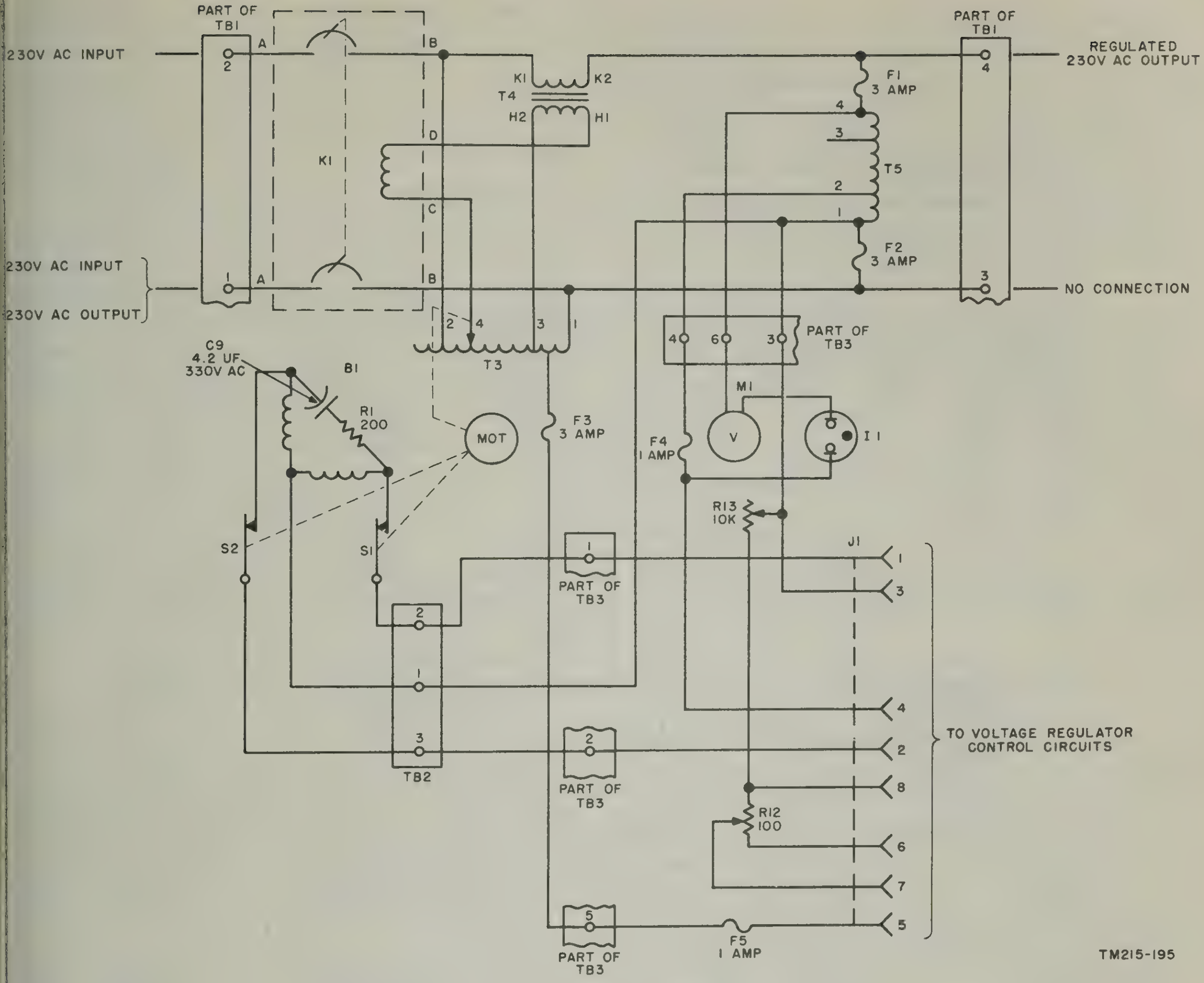


Figure 143. Power circuit, schematic diagram.

192. Control Circuit

(fig. 144)

The control circuit samples the regulated output at all times, and if the voltage departs from the normal preset value, it will energize the motor in the power circuit and restore the output voltage to the preset value.

a. Transformer T5, across the output of the voltage regulator (fig. 143), supplies 115 volts ac through terminal board TB3 and fuse F4 to operate the control circuit. Indicator lamp I 1 is across the 115-volt circuit and lights when power is applied to the control circuit.

b. The 115 volts ac is connected through receptacle J1 and plug P1 to the primary of transformer T1. The center-tapped secondary of T1 forms the ratio arms of a balanced bridge circuit. Voltage-sensitive resistor assembly R2 and output voltage control R12 are used in conjunction with the secondary of transformer T1 to complete the bridge circuit. Resistors R6 and R7 are stabilizers and are a part of the bridge circuit. The bridge output is obtained from the movable arm on output voltage control R12 and the center tap of T1 secondary.

c. When the output of the voltage regulator rises above the normal preset value, an unbalance of the bridge occurs, developing a voltage to energize coupling transformer T2. This condition causes a positive signal to be fed through protective resistor R3 to the grid of thyratron V1, causing it to conduct. Relay RL1, in the

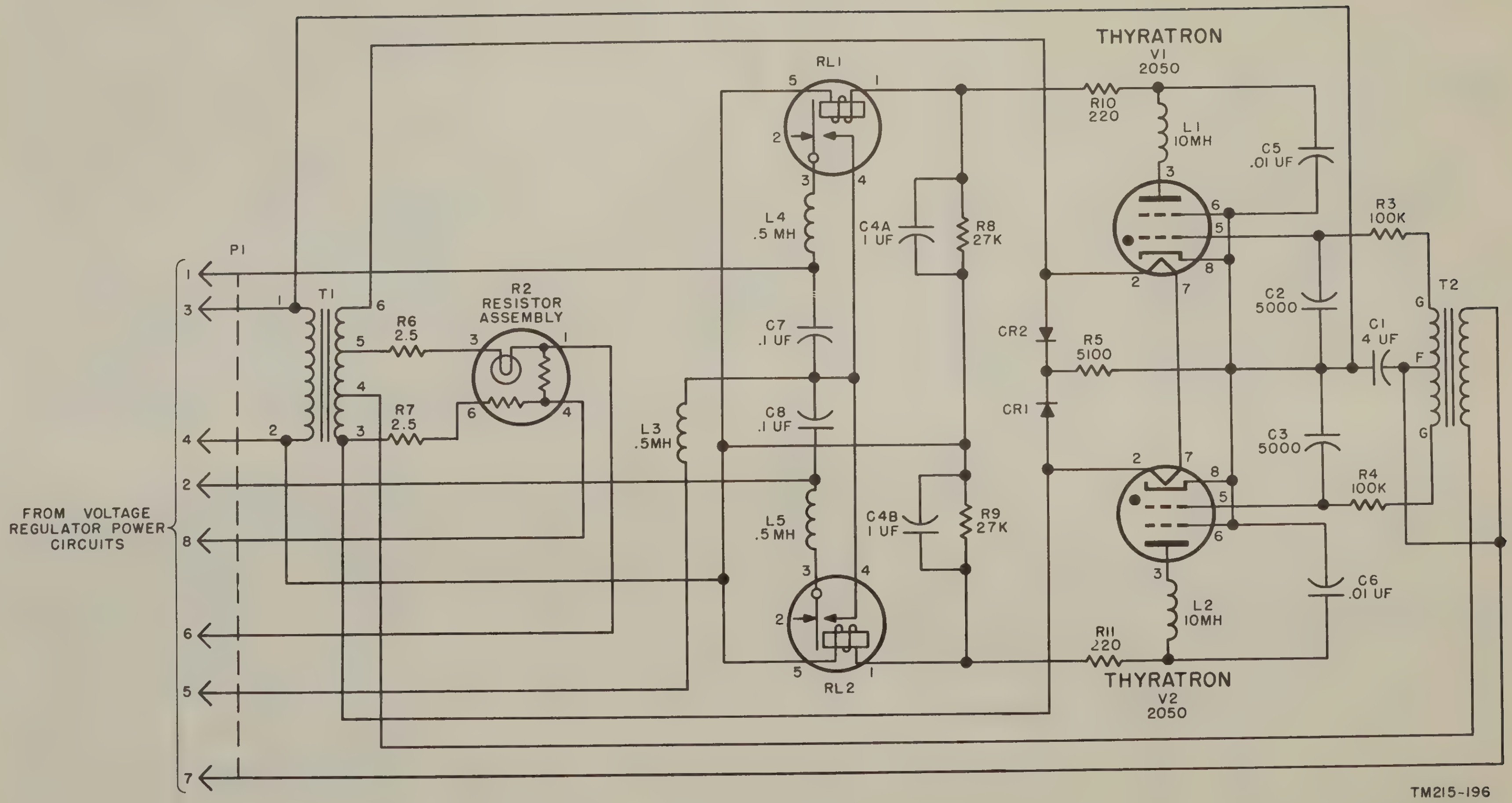


Figure 144. Control circuit, schematic diagram.

plate circuit of V1, is energized, and closes contact which supply power through terminal boards TB2 and TB3 to the proper winding of motor B1. Motor B1 rotates the variable power transformer brush to reduce the output voltage to the preset value.

d. When the output of the voltage regulator drops below the preset value, a similar sequence of events occurs, except that the positive signal is supplied through protective resistor R4 to the grid of thyratron V2, causing relay RL2 to operate and energize the motor in the opposite direction to correct the output voltage.

e. A positive bias is supplied to the cathodes of thyratrons V1 and V2. This bias is developed by CR1 and CR2 connected as a full-wave rectifier across the secondary of transformer T1. The output of the rectifiers is filtered by resistor R5 and capacitor C1. Sensitivity control R13, in series with a portion of resistor assembly R2, forms a bleeder across the bias supply. Sensitivity of the unit is determined by the bias applied to the cathodes of the thyratrons.

f. The output of thyratron V1 is connected through current-limiting resistor R10 to the parallel combination of the coil of relay RL1 and resistor R8. Plate voltage of 115 volts ac is obtained through resistor R8 from autotransformer T5. Inductors L1, L3, and L4 and capacitors C2, C4A, C5, and C7 prevent noise or RF radiation interference.

g. The output of thyratron V2 is connected through current-limiting resistor R11 to the parallel combination of the coil of relay RL2 and resistor R9. Plate voltage of 115 volts ac is obtained through resistor R9 from autotransformer T5. Inductors L2 and L5 and capacitors C3, C4B, C6, and C8 prevent noise or RF radiation interference.

h. The filaments of thyratrons V1 and V2 are connected in series and receive operating voltage from transformer T1.

Section XXIII. INTERUNIT THEORY OF AC POWER DISTRIBUTION CIRCUITS

193. General

The interunit theory of ac power distribution circuits in Radio Transmitting Set AN/FRN-22A is divided into four main groups and discussed in paragraphs 194 through 197. For complete circuit details, refer to the overall schematic diagram (fig. 148).

194. Powerline and Autotransformer Connections

(figs. 145–148)

Note. A number and a letter in parentheses following a reference number means that the part can be located on figure 148. For example (2,L) indicates that the part is at the intersection of 2 and L on figure 148.

The omnirange set requires 230 volts ac, 50- or 60-cycle, single-phase power. This power may be brought to the site as balanced 230 volts ac, with a neutral wire; balanced 230 volts ac, without a neutral wire; or as a single-ended, 230-volt ac line. Each type of power service requires a specific connection arrangement at the omnirange set to prevent circulating currents. Where line voltages differ consistently from 230 volts, alternate connections to autotransformer N/T1001 (1,L) are required.

a. When a balanced 230-volt ac input with neutral wire type of service is used (fig. 148), the line is brought into main breaker box N/S1001 (2,F) and connected directly to circuit breakers N/K1001 and N/K1015. The neutral wire is connected to the neutral bus bar in main breaker box N/S1001 and to the earth ground rod located in breaker box N/S1002 (2,L). The earth ground is also connected to the equipment shelter. Circuit breaker N/K1015 (2,F) feeds all the temperature-controlling heaters and blowers and is discussed in paragraph 196. Circuit breaker N/K1001 (2,G) feeds 230-volt ac power terminal board K/TB1 (terminals 1 and 2) to circuit breaker K/K1 (3,G) in Voltage Regulator CN-358/FRN-22. Output of the voltage regulator is taken from terminal board K/TB1 (terminals 1 and 4) and connects directly to the 230-volt taps of autotransformer N/T1001. The center tap and output from the autotransformer connect to load circuit breaker box N/S1002.

b. The connections for a balanced 230-volt ac input without a neutral wire are identical with the service that has a neutral wire, except that there is no connection to the neutral bus in circuit breaker box N/S1001 (fig. 158). The load neutral, center tap of autotransformer N/T1001, is connected to the shelter and earth ground of circuit breaker box N/S1002. This type of connection may also be used where local electrical codes

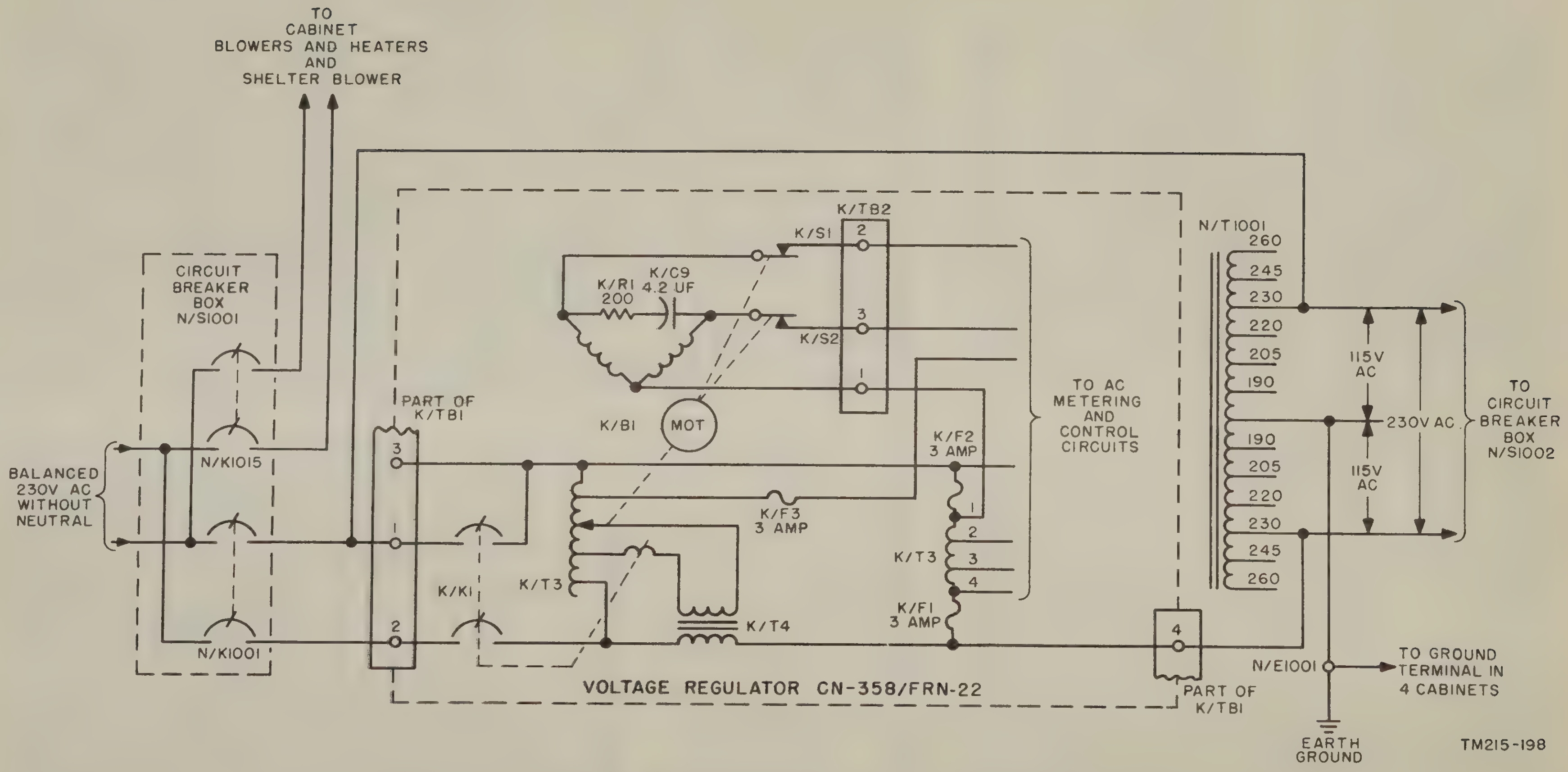


Figure 145. Powerline connections for balanced 230-volt ac input without neutral wire.

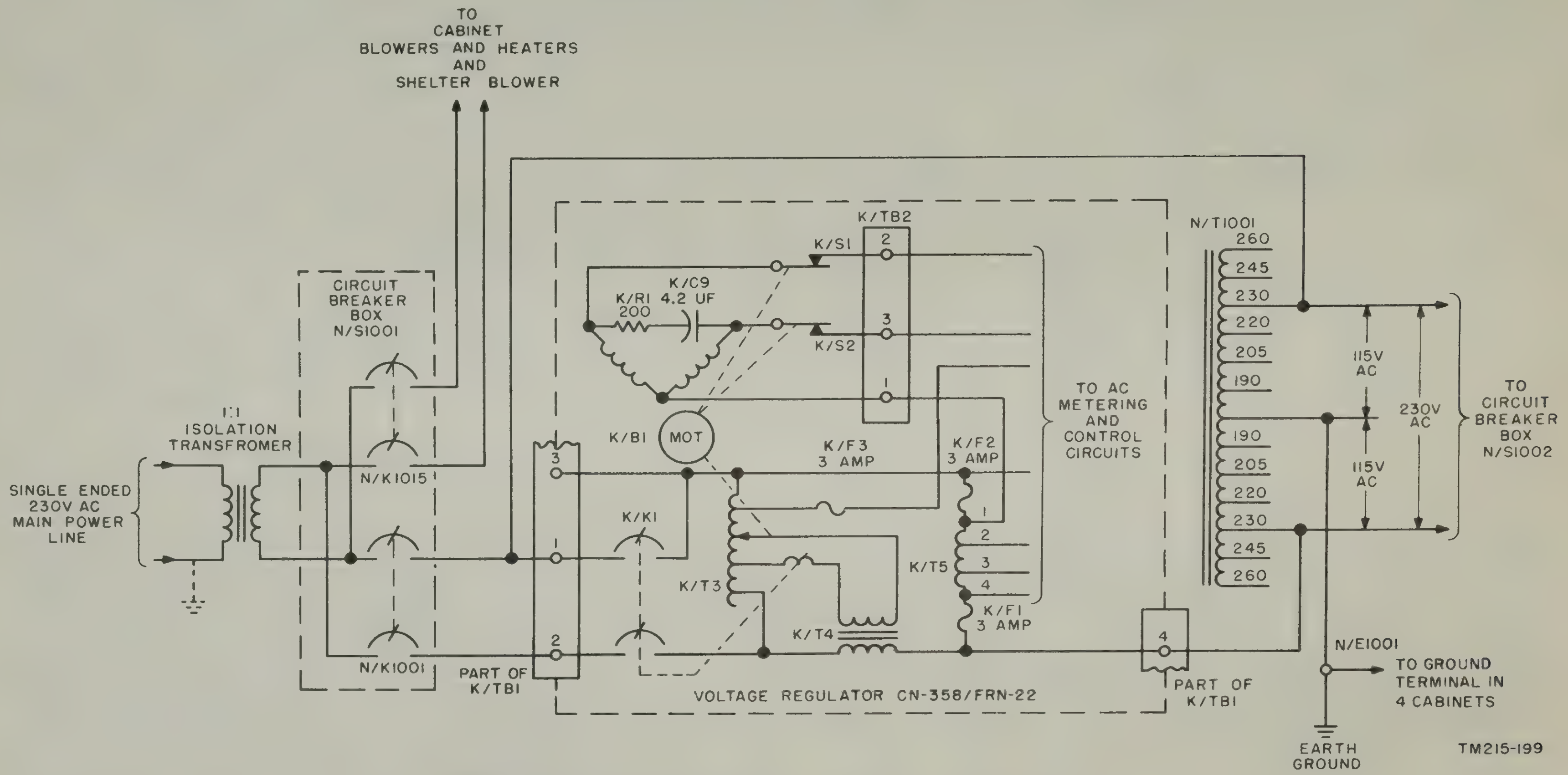


Figure 146. Powerline connections for single-ended 230-volt ac input.

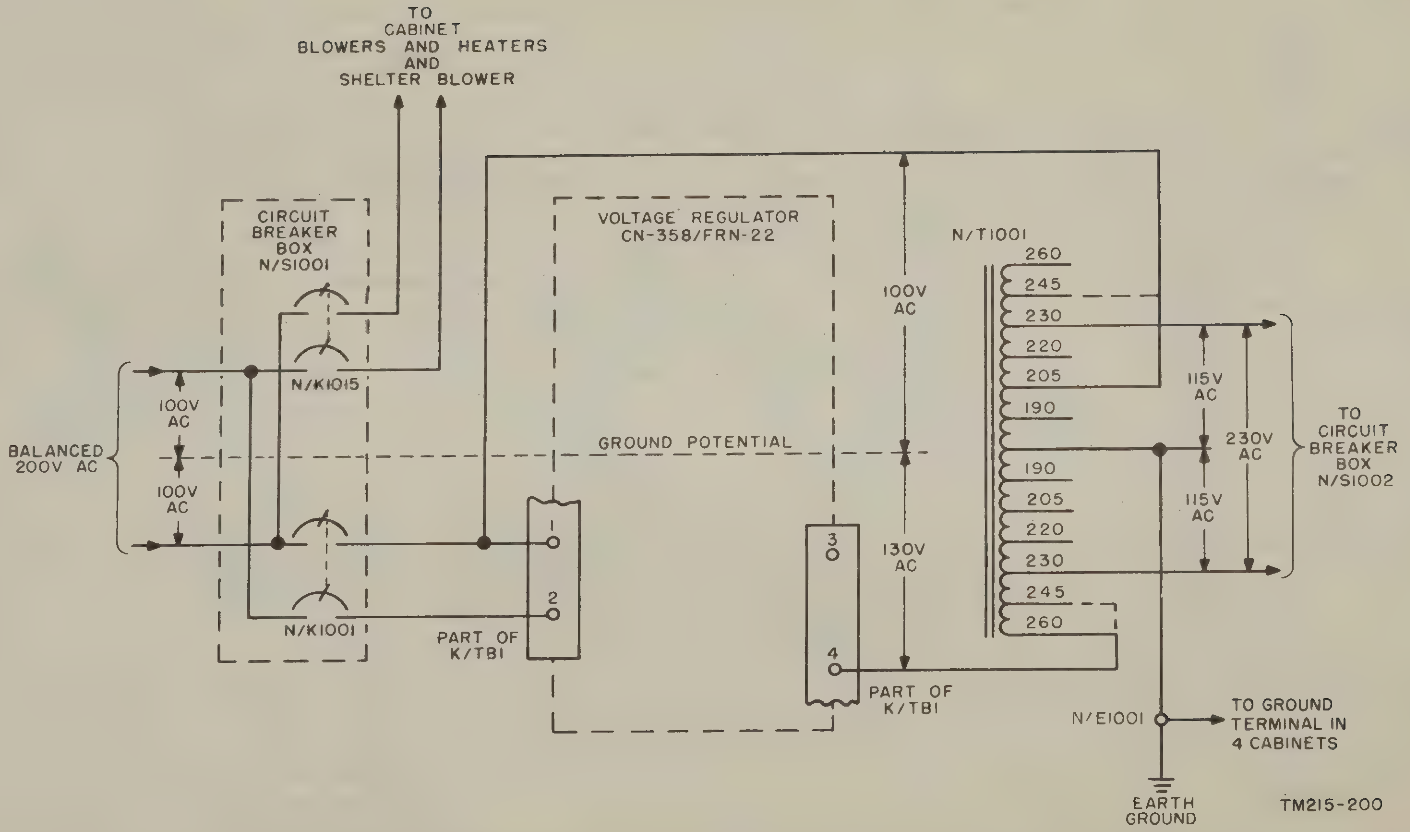


Figure 147. Autotransformer connections for a balanced input with low line voltage.

require an open neutral wire and a grounded load neutral.

c. For single-ended 230-volt ac input service, an isolation transformer must be used (fig. 146). Connections to autotransformer N/T1001 are identical with those required for a balanced 230-volt line without a neutral wire as the isolation transformer converts the single-ended line to the balanced form.

d. Balanced line inputs which are consistently below or above the normal 230-volt level will require repositioning of the leads on autotransformer N/T1001. Repositioning is required because the voltage regulator applies regulation between only one leg of the 230-volt line and ground. Adjustment is necessary to provide equal 115-volt ac lines at circuit breaker box N/S1002 for distribution. Figure 147 shows a sample connection used with consistently low line voltages.

195. Primary Power Distribution Circuits

(fig. 148, contained in separate envelope)

Power for equipment operation is brought into load circuit breaker box N/S1002 (1,K) from autotransformer N/T1001 (1,L). Circuit breaker box N/S1002 serves as the main power distribution box for the omnirange set. The 115-volt ac potentials are measured from a specific circuit breaker to the load neutral (center tap of autotransformer N/T1001).

a. Antenna heaters D/HR1 through D/HR4 (2,J) receive 115 volts ac from direct connections to circuit breaker N/K1002 (1,J).

b. Circuit breaker N/K1003 (1,G) supplies 115 volts ac through terminal board TB805 (terminals 3 and 4) and the ac wiring channel of the CY–1897/FRN–22 to receptacles J804 and J805 (8,G). Cable W11 (terminated by P825 and P826) carries power from receptacle J805 through receptacle J403, on the RE–247/FRN–22, to contacts 2L and 2R of relays O 401 and O 403 (8,D).

(1) Relay O 401, energized when No. 9 is dialed to warm up No. 1 equipment, applies power through connectors J402 and P813 (pins 3 and 4) to plug P814 (6,F), plug P815 (6,G), and terminals 3 and 4 of terminal board TB801 (3,D). Plug P814 supplies power to the O–373/FRN No. 1 (7,F), and plug P815 energizes keyer No. 1 (7,G). Power at 115 volts ac is applied to terminals 3 and 4 of terminal board TB1801 (10,C), from TB801 (terminals 3 and 4), for the following No. 1 equipment through connectors P1805 and B/J4 to the modulation eliminator (11,C); through terminal board TB1 (terminals 24 and 25) to PP–1331 (8,C); and through connectors P1808 and J1401 (pins U and V) to the PP–1329/FRN–20 (6,B). Terminal 4 of TB801 (3,D) also supplies power through TB802 (terminal 9) and pin 9 of connectors P808 and J401 (7,E) to TEST-OPERATE switch S401 of the RE–247/FRN–22. When switch S401 is in the OPERATE position, power is supplied through connectors J401 and P808 (pin 7) back through TB802 (terminal 10) to terminal board N/TB1001 in the antenna relay assembly (1,A). Neutral return for the antenna changeover relays is through N/TB1001 (terminal 2) to TB801 (terminal 3).

(*a*) The PP–1331/FRN–20 (8,B) power input at terminal board TB1 (terminals 24 and 25) is routed through fuses F1 and F2 to switch S2. When switch S2 is closed, 115 volts ac is applied to transformers T2 and T4, and the heater of 30-second time delay relay S3. Power is also fed from the PP–1331/FRN–20 through terminal board TB1 (terminals 13 and 15) to connectors P1806 and A/J1 (pins 13 and 15) at the transmitter (9,B). The load neutral, through interlock switch A/S3, is brought out of receptacle A/J1 (pin 14) to the interlock circuits (par. 197). Power at 115 volts ac, from terminal 13 of terminal board TB1 (8,B), is also fed to plug P1808 (pin M) of the PP–1329/FRN–20 (6,B) by the PP–1332/FRN–20.

(*b*) The power supplied to pin M of receptacle J1401 (6,B) provides *ready* power to the coil of plate relay K1402 in the PP–1329/FRN–20 (5,B). Relay K1402 will close when 30-second time delay relay S1401 (4,A) is closed and all interlock conditions are satisfied. The power which was supplied to pins V and U of receptacle J1401 (6,B) from energized relay O 401

(7,D) will energize main relay K1401 (4,B) and close contacts 1R/2R and 1L/2L.

(*c*) Circuit breaker N/K1011 (1,B) supplies 230 volts ac through terminals 1 and 3 of terminal board TB1803 (3,B), connectors P1808 and J1401 (pins G and S), fuses F1401 and F1402, and the closed contacts of relay K1401. Power is applied through fuses F1408 and F1409 to contacts 1R and 1L of plate relay K1402. Power at 230 volts ac from contacts 2R and 2L of relay K1401 (4,B) is applied through fuses F1403 and F1404 (4,A) to the center-tapped primary of transformer T1401. The heater of 30-second time delay relay S1401 is energized by 115 volts ac from one-half of the primary of transformer T1401. Power at 230 volts ac is supplied to transformer T901 of the O–371/FRN–20 (14,D) through fuses F901 and F902, connectors J902 and P/P1908 (pins 3 and 4), terminals 1 and 2 of terminal board P/TB1905 (15,B), and terminals 9 and 10 of terminal board TB1802 (12,A) by the output from pins D and O of receptacle J1401 (6,A) in the PP–1329/FRN–20. The 230-volt ac output through fuses F1405 and F1406 (5,A), connectors J1401 and P1808 (pins R and L), is applied to transformer G/T5 (14,E) in the AM–1246/FRN–20 through terminals 6 and 7 of terminal board TB1802 (12,A), terminals 5 and 7 of terminal board P/TB1905 (15,B), and pins 10 and 13 of connectors P/P1909 and G/J4 (15,F). The power for transformer G/T4 (14,F) is supplied, through fuses F1405 and F1407 (5,A) in the PP–1329/FRN–20, through pins F and R of receptacle J1401 (6,A), terminals 7 and 8 of terminal board TB1802 (12,A), and terminals 6 and 7 of terminal board P/TB1905 (15,B) to pins 11 and 13 of connectors P/P1909 and G/J4 (15,F) of the AM–1246/FRN–20.

(2) Power of 115 volts ac is supplied through circuit breaker N/K1003 (1,G), to contacts 2R and 2L of relay O 403 (8,D) and fed to pins 7 and 8 of receptacle J402 (9,D) of the RE–247/FRN–22 when No. 7 is dialed to warm up equipment No. 2. The power through plug P813 (pins 7 and 8) is routed to plug P816 for the O–373/FRN (11,H), plug P817 for the keyer (9,H), and to terminal board TB803 (terminals 3 and 4). Terminals 3 and 4 of terminal board TB1801 (10,J) receive the 115 volts ac from terminal board TB803 and supplies the modulation eliminator No. 2 (11,J) through connectors P1805 and B/J4. Power from terminal board TB1801 is also routed to terminals 24 and 25 of terminal board TB1 (8,K) of the PP–1331/FRN–20 and through connectors P1808 and J1401 (pins U and V) of the PP–1329/FRN–20 (6,K).

(*a*) The PP–1331/FRN–20 (8,J) power input at terminal board TB1 (terminals 24 and 25) is routed through fuses F1 and F2 to switch S2. When switch S2 is closed, 115 volts ac is applied to transformers T2 and T4 and the heater of 30-second time delay relay S3. Power is also fed out of the PP–1331/FRN–20 through terminal board TB1 (terminals 13 and 15) to connectors P1806 and A/J1 (pins 13 and 15) at the transmitter (9,K). The load neutral, through interlock switch A/S3, is brought out of receptacle A/J1 (pin 14) to the interlock circuits (par. 197). Power at 115 volts ac, from terminal 13 of terminal board TB1 (8,K), is also fed to plug P1808 (pin M) of the PP–1329/FRN–20 (6,K) by the PP–1331/FRN–20.

(*b*) The power supplied to pin M of receptacle J1401 (6,K) provides *ready* power to the coil of plate relay K1402 in the PP–1329/FRN–20 (5,K). Relay K1402 will close when 30-second time delay relay S1401 (4,L) is closed and all interlock conditions are satisfied. Energized power, which was supplied to pins U and V of receptacle J1401 (6,K) from relay O 403 (8,D) will energize main relay K1401 (4,K) and close contacts 1R/2R and 1L/2L.

(*c*) Circuit breaker N/K1012 (1,K) supplies 230 volts ac through terminals 1 and 3 of terminal board TB1803 (3,K), connectors P1808 and J1401 (pins G and S), fuses F1401 and F1402, and the closed contacts of relay K1401. Fuses F1408 and F1409 apply power to contacts 1R and 1L of plate relay K1402. Power at 230 volts ac through contacts 2R and 2L of relay K1401 (4,K) is applied through fuses F1403 and F1404 to the center-tapped primary of transformer T1401. The heater of 30-second time delay relay S1401 is energized by 115 volts ac from one-half of the primary of transformer T1401. Power at 230 volts ac is supplied to transformer T901 of the O–371/FRN–20 (14,J) through fuses F901 and F902, connectors J902 and P/P1912 (pins 3 and 4), terminals 1 and 2 of terminal board P/TB1906 (15,K), and terminals 9 and 10 of terminal board TB1802 (12,L) by the output from pins D and O of receptacle J1401 (6,L) in the PP–1329/FRN–20. The 230-volt ac output through fuses F1405 and F1406 (5,L), connectors J1401 and P1808 (pins R and L), is applied to transformer G/T5 (14,H) in the AM–1246/FRN–20 through terminals 6 and 7 of terminal board TB1802 (12,L), terminals 5 and 7 of terminal board P/TB1906 (15,K), and connectors P/P1913 and C/J4 (pins 10 and 13). The power for transformer G/T4 (14,H) is supplied through fuses F1405 and F1407 (5,L) in the PP–1329/FRN–20, pins F and R of receptacle J1401 (6,L), terminals 7 and 8 of terminal board TB1802 (12,L), and terminals 6 and 7 of terminal board P/TB1906 (15,K) to pins 11 and 13 of connectors P/P1913 and C/J4 of the AM–1246/FRN–20.

(3) Power supplied through circuit breaker N/K1003 (1,G) to receptacle J404 (8,E) through cable W9 is applied to contacts 2L and 2R of relays O 402 and O 404 (9,E). When No. 8 is dialed for equipment No. 1 operation, relay O 402 is energized. The 115 volts ac power is supplied through connectors J402 and P813 (pins 1 and 2), terminals 1 and 2 of terminal board TB801 (12,E), terminal board P/TB1905 (terminals 3 and 4), and connectors P/P1908 and J902 (pins 8 and 9) to contacts 3L/2L and 3R/2R of motor control relay K901 and the heater of 60-second time delay relay K902 (13,D). After the 60-second time delay, the 115 volts ac is applied to the coil of relay K901. Time delay relay K902 and relay K901 start goniometer motor C/B1 (10,B) on the normal powerline and then switch the motor to the output of the AM–1246/FRN–20 (14,D). The output applied through contacts 2L and 2R of relay K901 is fed through connectors J902 and P/P1908 (pins 10 and 11), terminals 1 and 2 of terminal board P/TB1903 (15,B), and terminals 1 and 2 of terminal board TB1801 (12,B) to plug P1803 at the goniometer (11,B). The 115-volt ac output applied through relay K901 in the O–371/FRN–20 (14,D) is fed to meters M1902 and M1903 (14,G) through terminal board TB1901 (terminals 2 and 4) and switch S1902 in the meter panel.

(4) Power is received at pins 5 and 6 of connectors J402 and P813 (10,E) when relay O 404 is energized by dialing 6 for No. 2 equipment operation. This power is routed through terminals 1 and 2 of terminal board TB803 (12,E), terminal board P/TB1906 (terminals 3 and 4), and connectors P/P1912 and J902 (pins 8 and 9) to relay K901 and the heater of 60-second time delay relay K902 (13,J). Relay K901 is energized by time delay relay K902. The contacts of relay K901 apply 115-volt ac power to pins 10 and 11 of receptacle J902 (14,K). Power from receptacle J902 (pins 10 and 11) is applied through terminals 1 and 2 of terminal board P/TB1904 (15,K), terminals 1 and 2 of terminal board TB1801 (12,L), and plug P1803 to the goniometer (11,K). Meters M1902 and M1903 (14,G) monitor the output of relay K901 (14,J) through switch S1902, terminal board TB1901 (terminals 3 and 5), and con-

nections to pins 10 and 11 of plug P/P1912 (15,J).

(5) Receptacle J405 (9,E) supplies power through cable W10 to operate the AN/FRA–14. Protection for this circuit is by fuse F401 (9,E) in the RE–247/FRN–22.

c. Circuit breaker N/K1004 (1,G) furnishes 115-volt ac power to the *permanently on* equipment through terminals 4 and 5 of terminal board TB805 (3,G) to the following receptacles and equipment: J803 (6,H) for the monitor through cable W8; J806 (9,G), not used; J807 for the PP–1415/FRN–22 (9,F) through cable W12; J802 (10,G), through cable W6 to the C–1840/FRN–22; J801 and J808, which are not used.

d. The 115 volts ac is supplied through circuit breaker N/K1005 (1,D) to shelter lights N/E1001 and N/E1002.

e. The 115 volts ac is supplied through circuit breaker N/K1105 (1,K) on the antenna pedestal, and to the obstruction light (2,H).

f. The 115 volts ac is supplied through circuit breaker N/K1007 (1,K) for convenience outlets J/J1001 and N/J1002 (2,L) on the antenna pedestal directly below load circuit breaker box N/S1002.

g. The remote control unit and the AM–1247/FRN–20, in the CY–1826/FRN–20, receive their ac power through cable W22, which may be connected to any 115-volt ac, 50- or 60-cycle, single-phase outlet.

196. Heating and Ventilating Circuits

(fig. 149)

All heaters and ventilators, except the antenna heaters, operate on 230 volts ac supplied through circuit breaker N/K1015.

a. The cable from the shelter blower connects directly to circuit breaker N/K1015.

b. The wiring for heaters and blowers of the two CY–1899/FRN–22's connects from circuit breaker N/K1015 to terminal board TB1803 (terminals 4 and 5). Connection from terminal 4 of TB1803 is through cabinet interlock S1802 to one side of blower motor receptacle J1804 and to terminal 1 of terminal board TB1804. Connection from terminal 5 of TB 1803 is through cabinet interlock S1803 to the common connection of thermostats S1804 and S1805 through thermostat S1804 to the other side of blower motor receptacle J1804, and through thermostat S1805 to terminal 2 of terminal board TB1804. Cabinet heaters HR1801 through HR1804 are connected across terminals 1 and 2 of terminal board TB1804.

c. Connections for the CY–1897/FRN–22 heaters and blower are made directly from circuit breaker N/K1015 to terminal board TB805 (terminals 1 and 2). The circuit within the cabinet is from terminal 1 of TB805 through cabinet interlock S801 to the common connection of thermostats S803 and S804, through thermostat S803 to one side of blower motor receptacle J809, and through thermostat S804 to terminal 2 of terminal board TB806. Connection is made from terminal 2 of terminal board TB805 through cabinet interlock S802 to the other side of blower motor receptacle J809 and to terminal 1 of terminal board TB806. Cabinet heaters HR801 through HR804 are connected across terminals 1 and 2 of terminal board TB806.

d. The heaters and blower in the CY–2274/FRN–22A receive 230 volts ac through circuit breaker N/K1015 through terminal board P/TB1909 (terminals 1 and 3). Within the CY–2274/FRN–22A, ac power is supplied from terminal 1 of P/TB1909 through cabinet interlock P/S1905 to the common connection of thermostats P/S1907 and P/S1908 and through thermostat P/S1908 to terminal board P/TB1902 (terminal 1), and through thermostat P/S1907 to terminal 1 of terminal board P/TB1908. From terminal 3 of terminal board P/TB1909 connection is made through cabinet interlock P/S1906 to terminal 2 of terminal boards P/TB1902 and P/TB1908. Cabinet heaters P/HR1901 through P/HR1904 connect across terminals 1 and 2 of terminal board P/TB1902. Receptacle P/J1901 for the blower motor connects across terminals 1 and 2 of terminal board P/TB1908.

197. Interlock and Protective Circuits

(fig. 150, contained in separate envelope)

Two 115-volt ac interlock circuits are provided for each transmitting equipment. Portions of the two interlock circuits in each equipment overlap. The interlock circuits for equipment No. 2 are identical with the circuits for equipment No. 1 (*a–c* below), except for the terminal numbers of the terminal board used in the CY-2274/FRN–22A.

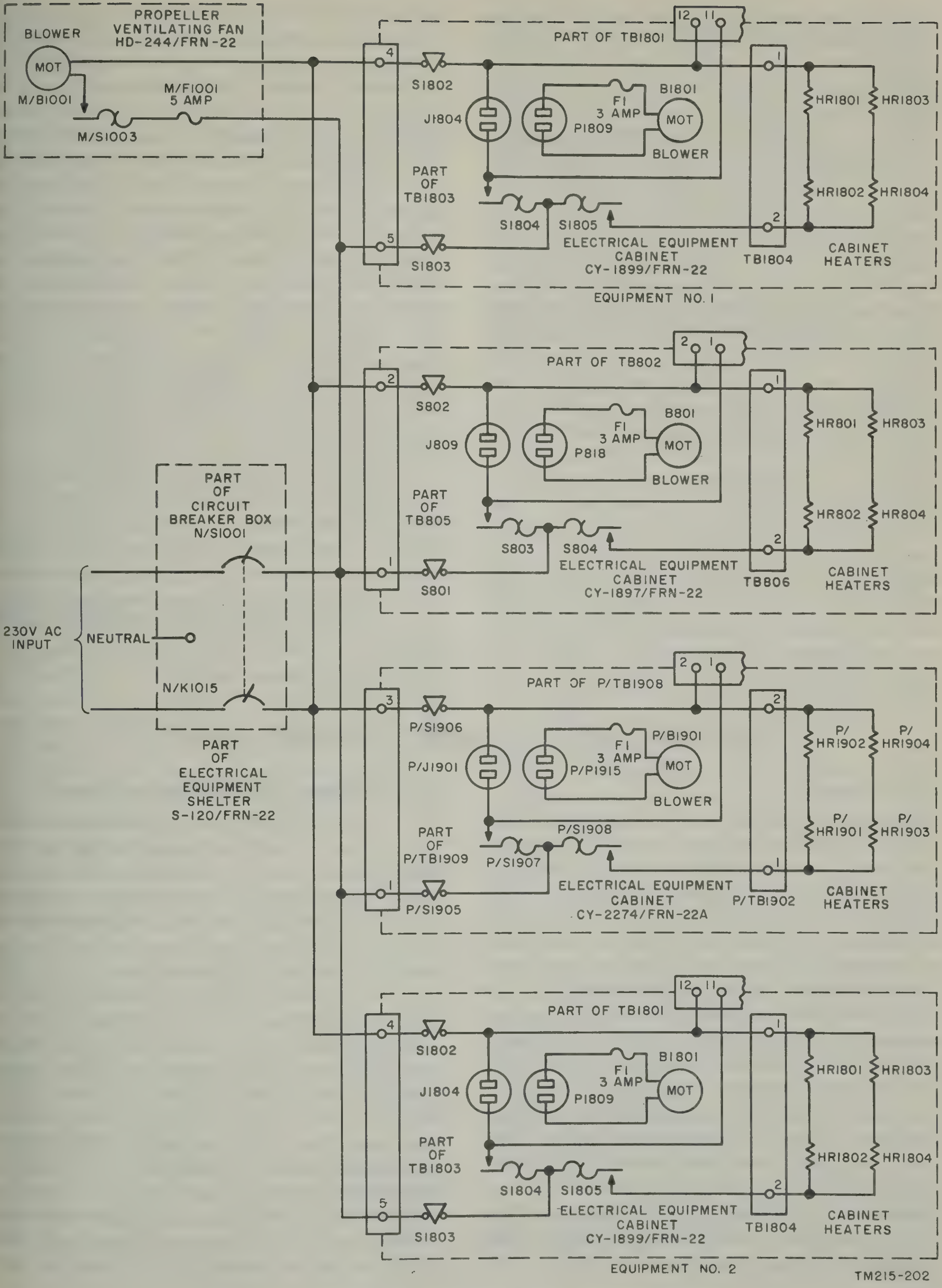


Figure 149. Heating and ventilating circuits, schematic diagram.

a. The two interlock circuits originate at the PP–1331/FRN–20. The 115 volts ac from the RE–247/FRN–22 is fed through the PP–1331/FRN–20 to terminals 13 and 15 of terminal board TB1 (fig. 148). The 115-volt interlock circuit is connected from terminal 15 of TB1 through receptacle A/J1 (pin 15), panel interlock A/S3, and back through receptacle A/J1 (pin 14) to terminal board TB1 (terminal 14). Terminal 14 of TB1 is connected through panel interlock S1 and out of power supply at terminal 28 at TB1. The interlock circuit from terminal 28 connects through cabinet door interlock S1801 of the CY–1899/FRN–22 to terminal board TB1 (terminal 29) and to terminal board TB1802 (terminal 12). Terminal 29 of TB1 feeds the primaries of plate transformers T1 and T3 in the PP–1331/FRN–20. This completes one interlock circuit.

b. The 115-volt circuit from terminal 12 of terminal board TB1802 is through the intercabinet wiring to terminal board P/TB1907 (terminal 3 for equipment No. 1; terminal 5 for equipment No. 2) in the CY–2274/FRN–22A. The interlock circuit from P/TB1907 is through receptacle G/J4 (pin 12), panel interlock G/S1, and the contacts of overload relay G/S2 to receptacle G/J4 (pin 9). The 115 volts ac is applied through receptacle G/J4 through cabinet door interlock P/S1903 for equipment No. 1, or P/S1904 for equipment No. 2, terminal board P/TB1907 (terminal 4 for equipment No. 1 or terminal 6 for equipment No. 2), and intercabinet wiring to terminal board TB1802 (terminal 11). The interlock circuit from terminal board TB1802 is connected through receptacle J1401 (pin N) and panel interlock S1402 to the contacts of thermal time delay relay S1401 in the PP–1329/FRN–20. After the contacts of relay S1401 close, the interlock voltage is fed to the coil of plate relay K1402, which energizes the +1,350-volt supply. The interlock circuit from relay K1402 connects through receptacle J1402 (pin M) to terminal board TB1 (terminal 13), which is the other side of the line. This completes the second interlock circuit.

c. Interlocks A/S3, S1, and S1801 will turn off the plate voltage to the transmitting circuits and the plate voltage to the regulating supply circuits. Interlocks A/S3, S1, S1801, G/S1, P/S1903 or P/S1904, and S1402 plus overload relay G/S2 and thermal time delay relay S1401 open the circuit to plate relay K1402, which in turn will turn off the plate voltage in the regulating supply circuits only.

Section XXIV. INTERUNIT THEORY OF CONTROL CIRCUITS

198. General

The control circuits of Radio Transmitting Set AN/FRN–22A comprise the following components: Power Supplies PP–1415/FRN–22 and PP–1331/FRN–20, Modulation Eliminator MX–1843/FRN–20, Radio Set Controls C–1739/FRN–20 and C–1738/FRN–20, Radio Set Transfer Control C–1840/FRN–22, Relay Assemblies RE–247/FRN–22 and RE–248/FRN–22, and Course Monitor MX–1837/FRN–20. The control circuits energize or shut down either equipment from the local or remote location by dial system. The control system also interrupts the identification tone during voice communications, performs automatic or manual transfer sequences, and prevents energizing both equipments at the same time. Control circuits and dial functions are discussed in paragraphs 199 through 202. For complete circuit details, refer to the overall schematic diagram (fig. 155).

199. Negative 12-Volt Control Power

(fig. 155, contained in separate envelope)

A negative 12 volts dc is supplied by the PP–1415/FRN–22 and is available to the control system at all times. The negative 12-volt dc circuit is divided into two branches: one is energized at all times, and the other is energized when the stock relay is deenergized.

a. The negative 12-volt dc branch, which is energized continuously, is taken from pin 31 of receptacle J205 (4, A) with respect to the chassis (pin 33) in the C–1738/FRN–20. This voltage is applied to contact 2R of relay O 201 (4, B) contact 3 of dial I 201 (5, C), and to pin 28 of receptacle J204 (8, C) in the C–1738/FRN–20 Intercabinet wiring applies the —12 volts dc through pin 22 of connectors P805 and J30 (8, A) to modulation eliminator test switch S301 through pin 1 of connectors P808 and J40 (9, B) to No. 2 equipment TEST switch S404 and through pin 16 of plug P801 to receptacle J602 (14, B) on the transfer unit. Within the C–1840/FRN–22, the dc voltage is applied to contact 5R of relay K601 (15, C), contact 2R of relay K602 (16, D), terminal 7 of time delay relay K606 (16, D), contact 5L of relay K603 (17, C), and contact 2R of relay K604 (18, C). All the —12-volt points referred to will be at —12 volts dc, with respect to ground, when circuit breaker N/K1004 is closed.

b. Negative 12-volt dc distribution, controlled by contacts 1R and 2R of stop relay O 203 (6, A), is also obtained from pin 31 of receptacle J205 (4, A) in the C–1738/FRN–20. From contact 2R of relay O 203, the —12 volts is applied to contact 2R of relay O 204 (7, B), pin 19 of receptacle J205 (8, B), and through limiting resistor R205 (7, C). Pin 19 of plug P803 (8, B) is connected to pin 19 of connectors P805 and J301, which apply power to contact 2R of relay O 301 (9, A). Because of the connection through stop relay O 203 (6, A), all equipments are deenergized when contacts 1R and 2R are opened by energizing stop relay O 203.

200. Positive 12-Volt Control Power

(fig. 155, contained in separate envelope)

A positive 12 volts dc is supplied from dry-disk rectifier D1 in the PP–1331/FRN–20 of the equipment selected. Power (+12 volts) for carrier control relay S5 is taken from the same supply and will energize whenever the control circuits, the transmitter test key, or the microphone push-to-talk switch supplies a ground return to relay S5.

a. The source of +12 volts dc in the control circuits is determined by the equipment selected for operation and service selector relay O 303 (10, E). Voltage from the No. 1 PP–1331/FRN–20 is fed to contact 9L of relay O 303, and No. 2 PP–1331/FRN–20 feeds contact 7L. Contact 8L of relay O 303 is the common +12-volt dc output fed through pin 6 of connectors J301, P805, P803, and J205 (8, E) to the coil of tone-voice relay O 208 (6, E) and through limiting resistor R204 to contact 1R of alarm trigger relay O 206 (7, E).

b. The coil of equipment No. 1 carrier control relay S5 (13, E) has a ground return path through terminal 22 of terminal board TB1 (12, E), terminal board TB1801 (terminal 6), terminal board TB802 (terminal 4), to pin 5 of plug P806 (11, E). In addition, a ground may be applied to terminal 22 of terminal board TB1 (12, E) by the TEST switch located on the front panel of the transmitter. Pin 5 of connectors P806 and J304 (10, E) is grounded by contacts 4R and 5R of equipment No. 1 omnirange relay O 205 (7, D), through pin 4 of connectors J301, P805, P803, and J205 (8, C), or through contacts 5L and 6L of relay O 303 (10, D), which is energized when equipment No. 1 is in warmup status.

c. Equipment No. 2 carrier control relay S5 (15, E) receives a ground return through terminal 22 of terminal board TB1 (14, C), terminal board TB1801 (terminal 6), terminal board TB804 (terminal 4), and pin 5 of connectors P807 and J303 (10, D). An additional ground source may be applied to terminal 22 of terminal board TB1 (14, C) by the TEST switch located on the front panel of the No. 2 transmitter. The ground to pin 5 of receptacle J303 (10, D) is supplied through contacts 2R and 3R of No. 2 omnirange relay O 302 (9, D), or through contacts 4L and 5L of service selector relay O 303 (10, D), which is deenergized during No. 2 equipment operation.

201. Alarm and Push-to-Talk Circuits

(fig. 155, contained in separate envelope)

The alarm and push-to-talk circuits of the remote control unit are carried over a simplex telephone line system from the remote to the local equipment location. The control circuits permit the technician at the local cite to command the omnirange set, maintain telephone contact with the remote operator, and place either omnirange set into normal or test operation. The local site does not have facilities for voice modulation of either transmitter, and during test operation, No. 1 equipment does not receive the tone identification signal. The remote operator has provisions that indicate the overall operation of the omnirange set, a microphone for voice communication, and a handset for telephone contact with the local site. The discussion in *a* through *i* below applies to the control circuits which command specific relay and switch functions only.

a. The coil of alarm trigger relay O 206 (7, E) receives a ground through pin 8 of connectors J205 and P803 (8, E), pin 2 of connectors P802 and F/J2 (11, E), and contacts 3R and 4R of integrated alarm relay F/RY4. Relay F/RY4, in the monitor, is energized when the omnirange set course information is within the preset tolerances. Negative 12-volt dc power to energize relay O 206 is supplied either by No. 1 equipment omnirange relay O 205 (7, D) or No. 2 equipment omnirange relay O 302 (9, D) as determined by the equipment selected for operation. Holding voltage for omnirange relay O 205 is supplied through the contacts of stop relay O 203 (6, A), contacts 2R and 3R of warmup relay O 204 (7, B), contacts 6R and 7R of omnirange relay O 205 (7, C), and contacts 6R and 7R of alarm trigger relay O 206 (7, E) during equipment No. 1 operation. Holding voltage for omnirange relay O 302 is supplied through the contacts of stop relay O 203 (6, A), contacts 2R and 3R of warmup relay O 301 (9, A), contacts 8R and 9R of omnirange relay O 302 (9, D), and contacts 4R and 5R of alarm trigger relay O 206 (7, E) during equipment No. 2 operation. If relays O 204 and O 205 or O 301 and O 302 fail to sequence properly or the monitor indicates incorrect omnirange set signals, relay O 206 will deenergize and remove the holding voltage from the appropriate omnirange relay to shut down the equipment in operation.

b. To maintain operational segregation in the simplex telephone line circuit, a polarity reversing alarm system is used. Alarm trigger relay O 206 supplies a postive dc voltage through contacts 1R and 2R (7, E) when deenergized and negative dc voltage through contacts 2R and 3R when energized. Therefore, either positive or negative voltage, dependent on equipment status, is applied through the coil of relay O 207 (5, E), contacts 10 and 11 of RING-TALK switch S201 (4, E) to the center-tapped primary of transformer T201 (4, D). The voltage is then fed through both sides of the simplex telephone line to the secondary of transformer T501 (3, D). The center tap of transformer T201 feeds the voltage through contacts 2C and 3C of push-to-talk relay O 501 (3, C) to the junction of rectifiers CR501 and CR502 (2, C). With the lever of ALARM SELECTOR switch S501 (1, C) in the center position, the rectifiers are paralleled by contacts 5 and 6 of switch S501 and will allow either the positive or negative voltage to be applied through contacts 8 and 9 of switch S501 to the coil of relay O 502 (2, C). The opposite coil connection of relay O 502 is to ground. Therefore, whenever current flows through one or both rectifiers CR501 and CR502, relays O 502 (2, C) and O 207 (5, E) will be energized.

c. The operational status of the omnirange set on the remote control unit is determined by the ALARM SELECTOR switch S501 (1, C) position and by observing TRANSMITTER ON indicator I 503, VOR ON indicator I 504, and buzzer I 502 (2, B). If neither transmitter equipment is energized, no dc voltage will be applied to rectifiers CR501 and CR502 (2, C), and relay O 502 will be deenergized. Setting switch S501 (1, C) in either the center or up position will cause buzzer I 502 (2, B) to be energized by a ground supplied through contacts 2 and 3 of relay O 502 (2, C) and contacts 10 and 11 of switch S501. Buzzer I 502 receives 6.3 volts ac through contacts 2R and 3R of push-to-talk relay O 501 (3, C) from the secondary of transformer T502 (1, D). However, by setting switch S501 in the down position, the ground to buzzer I 502 is broken. Indicators I 503 and I 504 (2, B) will not light because of the lack of a ground return through relay O 502.

d. While either transmitting equipment is in warmup status, a positive voltage is present at the junction of rectifiers CR501 and CR502 (2, C). With switch S501 (1, C) in the down position, rectifier CR502 will conduct and energize relays O 502 (2, C) and O 207 (5, E). Buzzer I 502 will sound because of the ground supplied through contacts 1 and 2 of relay O 502 and contacts 11 and 12 of switch S501 (1, B). TRANSMITTER ON indicator I 503 (2, B) glows because 6.3 volts ac is supplied through contacts 2 and 3 of switch S501 (1, C) and a ground from contacts 1 and 2 of relay O 502 (2, B). Moving switch S501 to the center position will silence buzzer I 502 by opening contacts 11 and 12 (1, B); all other conditions remain the same. Setting switch S501 in the up position will deenergize relay O 502 (2, C), because the current flow through rectifier CR502 now flows to ground through contacts 4 and 5 of switch S501 (1, C). The buzzer will sound because of the ground supplied by contacts 2 and 3 of relay O 502 and contacts 10 and 11 of switch S501. Indicator I 503 is turned off by contacts 2 and 3 of switch S501 (1, C) and the lack of a ground from relay O 502. Relay O 207 (5, E) remains energized because of current flow through rectifier CR502.

e. When the omnirange set is energized and operating normally, the voltage at the junction of rectifiers CR501 and CR502 (2, C) is negative. Relays O 502 (2, C) and O 207 (5, E) are energized by current flow through rectifier CR501 and contacts 5, 6, 8, and 9 of switch S501 (1, C) with the switch in the down or center position. Indicator I 503 will glow in these two positions because of closed contacts 2 and 3 of switch S501. With the switch in the down position, buzzer I 502 (2, B) will sound; in the center position, the buzzer will be silenced by open contacts 11 and 12 of switch S501 (1, B). Relay O 502 will remain energized when switch S501 is in the up position, because the current flow through rectifier CR501 is conducted through contacts 7 and 8 of switch S501 to the coil of relay O 502. Buzzer I 502 will be silent, indicator I 503 will go out, and VOR ON indicator I 504 will glow from power supplied by contacts 1 and 2 of switch S501. Any shutdown of the omnirange set will either reverse the polarity of the voltage to rectifier CR501 or remove the voltage entirely and deenergize relay O 502, sounding buzzer I 502 and extinguishing indicator I 504.

f. The push-to-talk switch (3, B) on the microphone furnishes a ground return to the coil of relay O 501 (3, C) through pins 1 and 4 of connectors P6 and J502 (3, B). Relay O 501 receives 6.3-volt dc power from the secondary of transformer T502 (1, D). Contacts 2C and 3C of push-to-talk relay O 501 interrupt the alarm circuit current flow, deenergizing relays O 502 (2, C), O 207 (5, E) and energizing tone-voice relay O 208 (6, E) with a ground supplied by contacts 1R and 2R of relay O 207 through RING-TALK switch S201 and LOCAL-REMOTE switch S202. Contacts 5L and 6L of relay O 208 (6, D) furnish a ground for carrier control relay S5 as determined by service selector relay O 303 (10, E). The remaining contacts of relay O 208 interrupt the tone identification signal and apply the voice signal to relay O 303 for distribution to the operating transmitter. Contacts 2L and 3L of relay O 501 (3, C) interrupt the simplex line from dial I 501 (2, D) and feed the audio output of AM–1247/FRN–20 to the input terminals of transformer T501 (3, D). Thus, the simplex telephone lines are clear of all currents except those produced for voice communication. Contacts 2R and 3R of push-to-talk relay O 501 (3, C) prevent buzzer I 502 (2, B) from sounding during voice communication by interrupting the 6.3-volt ac supply.

g. Placing RING-TALK switch S201 (4, E) in the RING position causes contacts 10 and 11 of the switch to open and interrupt the alarm circuit current flow through relays O 207 (5, E) and O 502 (2, C), and buzzer I 502 sounds. Tone-voice relay O 208 (6, E) does not energize because contacts 7 and 8 of switch S201 are also open. Placing switch S201 in the TALK position causes contacts 1, 2, 4, and 5 of the switch to close and connect local site handset HS2 to the simplex line and through normally closed contacts 1, 2, 4, and 5 of dial I 501 (2, D) to remote site handset HS2.
local dial I 201 (5, C) to pulsing relay O 202 (5, D) in the LOCAL position causes contacts 7 and 8 of the switch to close and prevent voice communications from the remote site. Contacts 4 and 5 of switch S202 open the circuit through local dial I 201 (5, C) to pulsing relay O 202 (6, C) from the remote site.

i. Switch S401 (12, A) provides a method by which transmitting equipment No. 1 may be placed in the warmup status from the local site without dialing 9. When switch S401 is closed (in TEST position), —12 volts dc is fed directly to the coil of No. 1 warmup relay O 401 (13, A). Moving switch S402 (11, A) in the ON position energizes equipment No. 1 omnirange relay O 402 (12, A) and omnirange set carrier output may be obtained by depressing the TEST switch on the front panel of the No. 1 transmitter. Voice and tone identification functions will be inoperative during this test because service selector relay O 303 (10, E) is not energized. Switches S403 (10, A) and S404 (9, A) perform the same functions in the No. 2 equipment, by energizing relays O 403 (11, A) and O 404 (10, A), and are interlocked with the switches of the No. 1 equipment to prevent operation of both equipments at the same time.

202. Dialing Functions

(figs. 151–155, contained in separate envelope)

The dialing functions which control the omnirange set are divided into groups (*a–i* below) which perform specific operations. These operations consist of local and remote dial circuits, equipment stop, warmup, normal omnirange output, and the automatic transfer system. The individual schematic diagrams, which are extracts from the overall schematic diagram (fig. 155), illustrate the circuits involved in a specific dial number function.

Note. Where a symbol is followed by a number and a letter in parentheses, refer to figure 155.

a. The operation of dial I 201 (5, C, fig. 168) on Radio Set Control C–1738/FRN–20 at the local site takes precedent over remote dial I 501 (2, D) in the remote control unit at all times. This control is maintained, regardless of the position of switch S202 (5, D), by contacts 1, 2, 4, and 5 of dial I 201 (5, C). When dial I 201 is rotated off the *home* position, contact 2 opens the circuit from the remote line and connects one side of the coil of pulsing relay O 202 (6, C) to the —12 volts dc present on contact 3 (5, C). Contact 5 of dial I 201 also opens the remote line and connects the other coil lead of relay O 202 to contact 6 which is at ground potential when dial pulsing contacts 7 and 8 are closed. Contact 2R of pulsing relay O 202 (6, C) receives —12 volts dc from the transfer unit when an automatic transfer cycle is not in progress. Cocking dial I 201 (5, C) will energize relay O 202, and —12 volts dc will be applied to contact 3R of slow release relay O 201 (4, B) and contact 11 of the *home* section of minor switch K201 (6, B). The home section of minor switch K201 insures that each dial sequence will start switch K201 from the same neutral position before stepping-off the pulses initiated by the dial. If minor switch K201 is at any position other than *home*, power will be supplied through contacts 7R and 8R of relay O 201 (4, B) directly to the release coil of minor switch K201 (5, B) and return the arm of the switch to the *home* position. When switch K201 is in the *home* position, contacts 11 and 12 (6, B) will energize slow release relay O 201 (4, B), and energize the step coil of switch K201 (5, B) into the ready position through contacts 8R and 9R of relay O 201 (4, B). Contact arm 2R of relay O 201 removes power from the arm of minor switch K201 and applies it to the C–1840/FRN–22 to reset it to the first cycle. Contacts 4R, 5R, and 6R of relay O 201 are used for audio muting. When dial I 201 (5, C) is released from the cocked position, contacts 2, 3, 5, and 6 remain closed but contacts 7 and 8 open and close, causing pulsing relay O 202 to deenergize and energize. Slow release relay O 201 (4, B) remains energized and conducts the pulses of relay O 202 to the step coil of minor switch K201 (5, B). The arm of switch K201 will be moved a number of steps in accordance with the number of pulses initiated by interrupter contacts 7 and 8 of dial I 201 (5, C). When dial I 201 reaches *home*, contacts 2, 3, 5, and 6 open, deenergizing relay O 202 (6, C) and slow release relay O 201 (4, B). Contacts 1R and 2R of relay O 201 apply —12 volts dc to the stepping arm of minor switch K201 (6, B) through the contact selected to the control circuits.

b. Dial I 501 (2, D), of the remote control unit, receives 115-volt ac power from the secondary of transformer T502 (1, D). When dial I 501 is cocked, contacts 2, 3, 5, 6, 7, and 8 are closed and apply the power to the primary of transformer T501 (3, D) if contacts 2L and 3L of push-to-talk relay O 501 (3, C) are closed. Ac power from the secondary of transformer T501 (3, D) is through the simplex telephone line and variable resistor R201 (4, C) to the input of bridge rectifier CR201 (4, C). The dc output from bridge rectifier CR201 is fed through limiting resistor R202 (5, C), contacts 4 and 5 of LOCAL-REMOTE switch S202 (5, D), and contacts 1, 2, 4, and 5 of dial I 201 (5, C) to the coil of pulsing relay O 202 (6, C). When dial I 501 (2, D) is released from the cocked position, contacts 7 and 8 interrupt the ac voltage from transformer T502 (1, D) and produce dc pulses from the output of bridge rectifier CR501 (4, C), which cause pulsing relay O 202 (6, C) to function the same as with local dial I 201 (5, C).

c. Dialing No. 10 will apply —12-volt dc power through contact 10 of minor switch K201 (6, B) to one side of the coil of stop relay O 203 (6, A). The other coil connection of relay O 203 receives a ground from contacts 6R and 7R of No. 1 warmup control relay O 204 (7, A) or contacts 6R and 7R of No. 2 warmup control relay O 301 (9, A) through pin 21 of connectors J205, P803, P805, and J301 (8, A). When stop relay O 203 energizes, contacts 1R and 2R (6, A) open and remove the negative 12 volts dc supplied to the coils of relays O 204 and O 301. Whenever relays O 204 and O 301 are deenergized, relays O 205 (7, D) and O 302 (9, D) will be deenergized and both equipments will shut down. These relays are discussed further in (1) through (5) below.

(1) *Dial number 9 function* (fig. 151). When 9 is dialed to warm up equipment No. 1, an arm of minor switch K201 moves to No. 9 contact and applies —12 volts to the coil of relay O 204. Relay O 204 energizes, furnishing a circuit for the —12 volts through contacts 1R and 2R of stop relay O 203, contacts 2R and 3R of relay O 204, to the coil of service selector relay O 303, and through test switch S401 to the coil of power relay O 401. Service selector relay O 303 energizes, selecting identification tone or voice from the No. 1 equipment and connects the No. 1 carrier control line to tone-voice relay O 208 to enable the operator to put the voice-modulated carrier on the air before the omnirange relays are dialed. Relay O 303 also selects the +12 volts from the No. 1 PP–1331/FRN–20 to be applied to the alarm circuit through contacts of relay O 206. Warmup relay O 401 applies 115 volts ac to the components of the omnirange set to start warmup action and energizes the antenna relays, connecting transmitter No. 1 to the antenna. Holding voltage for relay O 204, required when the arm of minor switch K201 is moved to another position, is applied from contacts 1R and 2R of stop relay O 203, through deenergized contacts 1R and 2R of equipment No. 2 warmup relay O 301, contacts 4R and 5R of relay O 204, as an interlock circuit to prevent energizing both equipments No. 1 and No. 2 at the same time.

(2) *Dial number 8 function* (fig. 152). When 8 is dialed, the —12 volts from minor switch K201 energizes equipment No. 1 omnirange relay O 205. The ground return for relay O 205 is through deenergized contacts 1R and 2R of equipment No. 2 omnirange relay O 302. This is an interlock to prevent operation of both equipments at the same time. EQUIPMENT NO. 1 indicator lamp I 202 is connected across the coil of relay O 205 and lights when O 205 energizes. Contacts 2R and 3R of warmup relay O 204 feed —12 volts through contacts 8R and 9R of relay O 205 to TEST switch S402 in the OFF position, to energize power relay O 402. Connection is also made from contact 9R of relay O 205 to plate relay B/K1, which energizes the plate voltage supply in the modulation eliminator. Contacts 6R and 7R of relay O 205 feed —12 volts to the coil of relay O 206. Relay O 206 will energize as soon as the monitor is satisfied and close the contacts of course alarm relay F/RY4. Contacts 6R and 7R of relay O 206 are the holding contacts for relay O 205. Contacts 4R and 5R of relay O 205 furnish a ground return for carrier control relay S5 in the PP–1331/FRN–20, which energizes the B+ supply for transmitter No. 1. Power relay O 402 in the power control unit turns on the ac voltage to the goniometer motor, and to the heater of motor control thermal relay K902 in O–371/FRN–20.

(3) *Dial number 7 function* (fig. 153). When 7 is dialed, the —12 volts from minor switch K201 energizes equipment No. 2 warmup relay O 301. The —12 volts from contacts 1R and 2R of stop relay O 203 is applied through deenergized contacts 1R and 2R of relay O 204, as an interlock, and then through contacts 4R and 5R of relay O 301 as a holding voltage for relay O 301. Another circuit from relay O 203, through contacts 2R and 3R of relay O 301, furnishes —12 volts through EQUIPMENT NO. 2 OPERATE switch S403 in the 460A position to energize power relay O 403. Contacts 6R and 7R of relay O 301 furnish a ground return for the coil of stop relay O 203. Power relay O 403 applies 115 volts ac to the components of the transmitting set to start warmup action. Service selector relay O 303 remains deenergized when the No. 2 equipment is operated because contacts 2R and 3R of relay O 204 are open.

(4) *Dial number 6 function* (fig. 154). When 6 is dialed, the —12 volts from

minor switch K201 energizes equipment No. 2 omnirange relay O 302. The ground return for relay O 302 is through deenergized contacts 1R and 2R of equipment No. 1 omnirange relay O 205. This interlock prevents dialing both equipments into operation at the same time. Contacts 2R and 3R of warmup relay O 301 feed —12 volts through contacts 6R and 7R of relay O 302 to TEST switch S404 in the OFF position. This energizes power relay O 404 and plate relay B/K1, which turn on the plate voltage supply in the modulation eliminator. Contacts 8R and 9R of relay O 302 feed —12 volts to the coil of relay O 206. Relay O 206 will energize as soon as the monitor is satisfied and close the contacts of course alarm relay F/RY4. Contacts 4R and 5R of relay O 206 are the holding contacts for relay O 302. Contacts 4R and 5R of relay O 302 furnish a ground return for carrier control relay S5, in the PP–1331/FRN–20, which energizes the B+ supply of the transmitter. Power relay O 404 in the power control unit applies ac voltage to the goniometer motor and to the heater of motor control thermal relay K902 in the O–371/FRN–20.

(5) *Dial number 5 function* (fig. 155). Number 5 must be dialed at the end of either equipment dialing sequence to provide a voltage command to the C–1840/FRN–22, which will cause the C–1840/FRN–22 to cycle from an equipment failure. The arm of minor switch K201 (6, B) applies —12 volts dc through contact 5, pin 5 of connectors J205 and P803 (8, B), and pin 1 of connectors P801 and J602 (14, B) to contact 2R of transfer trigger relay K601 (15, C). Relay K601 is energized during normal operation of the omnirange set, and contacts 1R and 2F or relay K601 (15, C) are open.

d. C–1840/FRN–22 Circuits (fig. 155). The complete theory of operation of the C–1840/FRN–22 is contained in paragraph 187. This discussion is limited to interconnection with the equipment control circuits. When dial I 501 (2, D) or dial I 201 (5, C) is cocked, contacts 2R and 3R of relay O 201 (4, B) are closed and supply —12 volts dc to pin 13 of connectors J205 and P803 (8, B) and pin 11 of connectors P801 and J602 (14, B) to contact 12 of *off normal* section K605D (17, A) of minor switch K605. If minor switch K605 is not at the number 1 position, voltage will be applied through contact 11 to the release coil which will reset the switch to number 1. Contacts 12 and 13 of switch K605D (17, A) will close, applying —12 volts dc to the coil of trigger relay K601 (15, D). Trigger relay K601 will energize if the monitor is satisfied and relay F/RY4 (12, E) is energized, through the ground connection supplied by pin 2 of connectors F/J2 and P802 (11, E) and pin 8 of connectors P801 and J602 (14, C). When no transfer cycles are in progress, contacts 4L and 5L of relay K603 (17, C) and contacts 7R and 8R of dial disabling relay K602 (16, C) supply —12 volts dc through pin 17 of connectors J602 and P801 (14, B) and pin 29 of connectors P803 and J205 (8, C) to contact 2R of pulsing relay O 202 (6, C). Minor switch section K605A (15, A), performs dial 9 functions at positions 1, 3, and 5 or dial 7 functions at positions 2, 4, and 6 during transfer cycles. Section K605B (16, A) performs dial 8 functions at positions 2, 4, and 6, or dial 6 functions at positions 3, 5, and 7. Dial 10 functions are completed by switch section K605B at position 8.

Section XXV. INTERUNIT THEORY OF FREQUENCY-REGULATED SUPPLY CIRCUITS

203. General

A frequency-regulated supply, consisting of Indicator Panel SB–830/FRN–22A, Audio Frequency Oscillator O–371/FRN–20, Audio Frequency Amplifier AM–1246/FRN–20, and Power Supply PP–1329/FRN–20, is incorporated in Radio Transmitting Set AN/FRN–22A. The PP–1329/FRN–20 generates a voltage of 115 volts ac that is frequency regulated at either 50 or 60 cps and is used to drive the motor in the goniometer. For ease of discussion, only the operational theory for equipment No. 1 will be outlined. However, with the exception of reference designators, such as pins and terminals, the theory given for equipment No. 1 applies equally to equipment No. 2. For complete details, refer to the overall schematic diagram (fig. 156).

204. Signal Circuits

(fig. 156, contained in separate envelope)

a. The 50- or 60-cycle signal of approximately 1.5 volts is developed in the O–371/FRN–20. The output of the O–371/FRN–20 (pins 3 and 4 of receptacle J901) is applied to pins 2 and 3 of connectors P/P1909 and G/J4 on the AM–1246/FRN–20. The amplified output signal is at the plate caps of tubes G/V4 and G/V5 (working as a push-pull amplifier) and is applied to standoff terminals P/E1902 and P/E1906 for equipment No. 1. Signal flow from this point is through a cabinet interconnect wiring harness to standoff terminals E1801 and E1802 in the CY–1899/FRN–22. Connections are then made directly to the secondary (terminals 5 and 9) of transformer T–1403 in the PP–1329/FRN–20.

b. A voltage of 115 volts ac at the regulated frequency is induced into the secondary of T1403 and fed through receptacle J1401 (pins A and C) on the PP–1329/FRN–20, terminal board TB1802 (terminals 3 and 5), terminal board P/TB1908 (terminals 6 and 8), and receptacle J902 (pins 5 and 7) on the O–371/FRN–20 to the contacts of motor control relay K901. Approximately 60 seconds after applying ac power (by dialing 9, then 8) to a thermal relay, motor control relay K901 energizes, applying this frequency-regulated voltage to the goniometer motor through receptacle J902 (pins 10 and 11), terminal board P/TB1903 (terminals 1 and 2), terminal board TB1801 (terminals 1 and 2), and connectors P1803 and C/J6.

205. Metering Circuits

(fig. 156, contained in separate envelope)

a. Facilities for monitoring either of the PP–1329/FRN–20 circuits is provided by the meter panel (fig. 232). Metering circuits may be switched from one equipment to the other by means of two rotary switches, S1901 and S1902. Connections are made between receptacle J902 (pins 10 and 11) on the O–371/FRN–20 and terminal board TB1901 (terminals 2 and 4 for equipment No. 1) on the meter panel. These connections are parallel with the motor and indicate the voltage and frequency of the power applied to the motor.

b. The driver (tubes G/V2 and G/V3) total current measurement is accomplished by connecting meter M1901 on the meter panel through switch S1901A (terminal 2), terminal board TB1901 (terminal 7), and pin 7 of receptacle G/J4 on the AM–1246/FRN–20 across resistor G/R3 in the cathode circuit of the driver stage.

c. Amplifier (tubes G/V4 and G/V5 in amplifier) total current measurement is accomplished by connecting meter M1901 on the meter panel through switch S1901A (terminal 1), terminal board TB1901 (terminal 6), and pin 8 of receptacle G/J4 on the AM–1246/FRN–20 across resistor G/R8 in the cathode (filament return) circuit of the final amplifier stage. Center contacts of motor control relay K901 are connected in series with the cathode return circuit of the final amplifier (tubes G/V4 and G/V5) stage and prevent current from flowing in this circuit until the relay is energized. This connection is from pins 5 and 6 of receptacle J901 on the O–371/FRN–20 to pins 4 and 5 of receptacle G/J4 on the AM–1246/FRN–20.

206. B+ Circuits

(fig. 156, contained in separate envelope)

a. The B+ circuits for the O–371/FRN–20 are all self-contained and are covered adequately in the unit theory section.

b. The B+ voltages for the AM–1246/FRN–20 are obtained from the PP–1329/FRN–20. The 500-volt dc output of the low-voltage section of the power supply is at pin J of receptacle J1401. Connection is then made through plug P1808, terminal board TB1802 (terminal 1), and terminal board P/TB1907 (terminal 7 for equipment No. 1) to high-voltage receptacle G/J3 on the amplifier. The 1,350-volt dc output of the power supply is applied to the center tap of the primary winding of transformer T1403 and from there is applied to the plate caps of tubes V4 and V5 in the AM–1246/FRN–20.

c. A dc control voltage is taken from the arm of REGULATOR control R920 in the O–371/FRN–20. This control voltage is fed through pin 6 of receptacle J902 and plug P/P1908 to terminal board P/TB1908 (terminal 7) and, through a wiring harness, to terminal board TB1802 (terminal 4) and then to pin B of receptacle J1401. This voltage is applied to the center tap of the primary winding of transformer T1403; it is a threshold voltage that is fed back to the cathodes of an agc detector in the O–371/FRN–20 to regulate the output of the oscillator.

Section XXVI. INTERUNIT THEORY OF TRANSMITTING CIRCUITS

207. General

Dual transmitting circuits, each consisting of Power Supply PP–1331/FRN–20, Radio Transmitter T–573/FRN–20, Modulation Eliminator MX–1843/FRN–20, and the goniometer capacitor on Electrical Goniometer GO–12/FRN–20, are incorporated in Radio Transmitting Set AN/FRN–22A. The antenna relay assembly and Antenna AT–669/FRN–22 are considered a portion of both transmitting circuits. For complete circuit details, refer to the overall schematic diagram (fig. 157).

208. Transmitting Signal Circuit

(fig. 157, contained in separate envelope)

a. The RF signal generated in either the equipment No. 1 or the equipment No. 2 transmitter is fed through the output cable and plug A/P1 to receptacle B/J2 on the modulation eliminator. Receptacle B/J2 is paralleled to receptacle B/J1 in the modulation eliminator and feeds the RF signal through a coaxial cable to receptacle J1802 in the top of the CY–1899/FRN–22. The modulation eliminator extracts a portion of the RF signal from receptacle B/J2 and removes the modulating components. The output of the modulation eliminator is fed through cable W1 to INPUT receptacle C/J4 of goniometer capacitor C/C17. The two outputs of goniometer capacitor C/C17 are connected through coaxial cables from receptacles C/J3 and C/J5 to receptacles J1801 and J1803 at the top of the CY–1899/FRN–22.

b. The reference carrier signal from either transmitting equipment is fed through coaxial cables from the top of the respective CY–1899/FRN–22 to the antenna changeover relays. For equipment No. 1, the reference carrier signal from receptacle J1802 is fed through coaxial cable W14 to receptacle N/J1008 on the antenna changeover relay assembly. Antenna changeover relay N/K1010, energized for equipment No. 1 operation, feeds the reference carrier signal through receptacle N/J1007 and phasing cable W5 connected to coaxial cable W3 to the reference carrier section of the antenna. The reference carrier is then radiated omnidirectionally from the antenna and carries the subcarrier modulation plus the station identification tone or voice signal modulation. One variable carrier signal, from receptacle J1801, is fed through coaxial cable W13 to receptacle N/J1005. Antenna changeover relay N/K1008, energized for equipment No. 1 operation, feeds the RF signal through receptacle N/J1004 and coaxial cable W2 to one variable carrier section of the antenna. The second variable carrier signal, from receptacle J1803, is fed through coaxial cable W15 to receptacle N/J1011. Antenna changeover relay N/K1009 feeds the RF signal through receptacle N/J1010 and coaxial cable W4 to the other variable carrier section of the antenna. The two variable carriers are radiated as figure-of-eight patterns which add vectorially to produce one rotating figure-of-eight pattern. The rotating figure-of-eight pattern then adds vectorially with the reference carrier pattern to produce the rotating eccentric lobe pattern.

c. The reference and variable carrier signals for equipment No. 2 are fed through coaxial cables W16, W17, and W18 to the antenna changeover relays. The antenna changeover relays (N/K1008, N/K1009, and N/K1010) are deenergized for equipment No. 2 operation and feed the RF signals through coaxial cables W2, W3, and W4 to the proper sections of the antenna.

209. B+ and Bias Circuits

(fig. 157, contained in separate envelope)

a. The B+ voltages of +250 and +500 volts are developed by the PP–1331/FRN–20. The +250 volts dc is applied through terminal board TB1 (terminal 7) and receptacle A/J1 (pin 7) to supply operating voltage for tubes of the transmitter. The +500 volts is applied through terminal E1 and receptacle A/J2 to supply operating voltage for final amplifier A/V4.

b. Bias voltages of −25 and −75 volts dc are developed in the PP–1331/FRN–20. The −25 volts dc is applied through terminal board TB1 (terminal 12) and receptacle A/J1 (pin 12) to the grid of A/V3, the second doubler amplifier. The −75 volts dc is applied through terminal board TB1 (terminal 11) and receptacle A/J1 (pin 11) to the grids of A/V4, the final amplifier.

Section XXVII. INTERUNIT THEORY OF MODULATING SIGNAL CIRCUITS

210. General

The modulating signal circuits consist primarily of the subcarrier signal circuit and the identification tone circuit. However, circuits for voice modulation from the remote control point are available and employ a portion of the identification tone circuit. For complete circuit details, refer to the overall schematic diagram (fig. 158).

211. Subcarrier Modulating Signal Circuits

(fig. 158, contained in separate envelope)

The subcarrier modulating signal circuits for equipment No. 1 comprise circuits within the goniometer and transmitter. The subcarrier modulating signal that originates in the subcarrier section of the goniometer is applied through receptacles C/J1 (pin 1) and C/J7 (pin 3) to attenuator C/R18. Attenuators C/R18 and C/R17 combine the subcarrier signal with the identification tone or voice signal and feed the combined signal through receptacle C/J 7 (pin 8) and terminal board TB1 (terminal 21 shorted to terminal 6) to receptacle A/J1 (pin 6), where it is applied through attenuator A/AT1 to the modulator section of the transmitter. The path of the subcarrier modulating signal is the same for equipment No. 2.

212. Identification Tone Circuits

(fig. 158, contained in separate envelope)

The identification tone circuits for equipment No. 1 consist of Audio Frequency Oscillator O–373/FRN, Keyer KY–175/FRN, portions of Relay Assembly RE–248/FRN–22, Radio Set Control C–1738/FRN–20, Radio Set Transfer Control C–1840/FRN–22, Electrical Goniometer GO–12/FRN–20, and Radio Transmitter T–573/FRN–20.

a. The 1,000-cycle identification tone that originates in the O–373/FRN is applied through receptacle E/J2 (terminals 1 and 4) to keyer terminal board L/TB501 (terminals 6 and 2). The keyer interrupts this tone to produce the station identification code. The keyer tone is then applied through terminal board L/TB501 (terminals 1 and 2) and receptacle J304 (terminals 1 and 2) to the contacts of service selector relay O 303.

b. Service selector relay O 303, energized for equipment No. 1 and deenergized for equipment No. 2, selects the keyed tone from the appropriate O–373/FRN and keyer. The keyed tone is applied from the contacts of relay O 303 through J301 (pins 12 and 13) and receptacle J602 (pins 12 and 13) to the contacts of relay K604. Relay K604 energizes during a transfer cycle and terminates the keyed tone circuit in a 470-ohm resistor for muting. With relay K604 deenergized, the keyed tone is applied through receptacle J602 (pins 13 and 14) and receptacle J205 (pins 12 and 13) to tone-voice relay O 208, which selects the keyed tone when deenergized or the voice-modulating signal when energized.

c. A common circuit for the keyed tone and voice signals is applied from the contacts of relay O 208 through capacitor C202, filter FL201, and receptacle J205 (pins 10 and 11) to the RE–248/FRN–22. The input to the RE–248/FRN–22 at receptacle J301 (pins 10 and 11) is applied to the contacts of service selector relay O 303. Relay O 303, energized for equipment No. 1, feeds the modulating signal through receptacle J304 (pins 3 and 4) to terminal board TB802 (terminals 7 and 8). The signal path for the modulating signal is then through the intercabinet wiring harness, terminal board TB1801 (terminals 9 and 10), and receptacle C/J7 (pins 1 and 2) to attenuator C/R17. Attenuator C/R17, working with attenuator C/R18, combines the identification tone or voice signal with the subcarrier signal and feeds the combined signal through receptacle C/J7 (pin 7) and terminal board TB1 (terminal 20 shorted to terminal 3) to receptacle A/J1 (pin 3), where it is applied through attenuator A/AT1 to the modulator section of the transmitter. The theory of operation for the identification tone circuit in equipment No. 2 is identical with that for equipment No. 1. Minor deviations exist in reference designations for receptacles and terminal boards. The only notable difference is the reciprocal action of service selector relay O 303. It is energized for operation with equipment No.

1 and deenergized for operation with equipment No. 2.

213. Voice Signal Circuits

(fig. 158, contained in separate envelope)

The voice signal circuits for either equipment No. 1 or equipment No. 2 consist of Audio Frequency Amplifier AM–1247/FRN–20 and portions of Radio Set Control C–1739/FRN–20, Radio Set Control C–1738/FRN–20, Relay Assembly RE–248/FRN–22, Electrical Goniometer GO–12/FRN–20, and Radio Transmitter T–573/FRN–20.

a. Voice modulation can be accomplished any time after the equipment has been placed in warmup condition by closing the press-to-talk switch and speaking into microphone MK1. The press-to-talk switch supplies a ground return to press-to-talk relay O 501. Relay O 501 energizes, opening the simplex line, which causes simplex control relay O 207 to deenergize. Deenergized contacts of relay O 207 furnish a ground for tone-voice relay O 208. Relay O 208, energized, completes the circuits for voice modulation and opens the circuits for identification tone modulation. Relay O 208 also completes the carrier control circuit so that voice-modulated carrier may be transmitted after either warmup or omnicondition has been dialed.

b. The microphone plugs into receptacle J502 on the remote control unit, and connections are made from J502 (pins 2 and 3) through terminal board E501 (terminals 3 and 4) to input receptacle J/J1 (pins 2 and 3) on the AM–1247/FRN–20. Output of AM–1247/FRN–20 receptacle J/J2 (pins 1 and 4) is fed through terminal board E501 (terminals 5 and 6), the energized contacts of relay O 501, and the deenergized contacts of dial I 501 to transformer T501. The signal is then coupled to the secondary of T501 and through terminal board E501 (terminals 1 and 2) and over the telephone line to terminal board TB804 (terminals 1 and 2) in the CY–1897/FRN–22. The signal path is through terminal board E201 on the C–1738/FRN–20 to transformer T201. The output of the transformer secondary is fed through the deenergized contacts of slow release relay O 201, contacts of RING-TALK switch S201 in the neutral position, and contacts of LOCAL-REMOTE switch S202 in the REMOTE position to the contacts of tone-voice relay O 208, which (when energized) completes the voice-modulation signal circuits. Circuits from relay O 208 to the modulator are common to both tone and voice-modulating signals and are discussed in paragraph 212*c*.

Section XXVIII. INTERUNIT THEORY OF MONITORING AND ALARM CIRCUITS

214. General

The monitoring and alarm circuits sample and monitor the radiated signal to signal an alarm by means of lamps and a buzzer if an improper signal is being radiated. Facilities that enable the operator to aurally monitor the signal are also provided.

215. Alarm Monitoring Circuits

(fig. 159, contained in separate envelope)

The alarm monitoring circuits consist of Antenna Group AN/FRA–14, Course Monitor MX-1837/FRN–20, and portions of Radio Set Controls C–1738/FRN–20 and C–1739/FRN–20.

a. The AN/FRA–14 samples the radiated signal, detects it, and feeds the detected signal through coaxial cable W7 to receptacle F/J1 on the monitor. The monitor separates the detected signal into three components (reference, variable, and audio signals) and feeds them through their respective channels.

b. Amplitude and phase-sensitive circuits indicate any change in the signal by means of meters and alarm lights on the monitor. When these changes reach a predetermined level, alarm relay F/RY4 deenergizes, breaking the ground return to alarm trigger relay O 206 in the C–1738/FRN–20. This ground return connects contacts of relay F/RY4 through receptacles F/J2 (pin 2) and J205 (pin 8) to the coil of relay O 206. Relay O 206 deenergizes, changing the simplex voltage on the telephone line from negative to positive and causing the green VOR ON pilot lamp on the remote control unit to go out and buzzer I 502 to sound. Alarm selector switch S501, located on the remote control unit, may be changed to the center position to silence the buzzer and light the amber TRANSMITTER

ON pilot lamp. When anything happens to cause the loss of simplex voltage, buzzer I 502 sounds with alarm selector switch S501 in either upper or center position and both pilot lamps go out.

216. Aural Monitoring Circuits

(fig. 159, contained in separate envelope)

The aural monitoring circuits consist of portions of Course Monitor MX–1837/FRN–20 and Radio Set Controls C–1738/FRN–20 and C–1739/FRN–20.

a. The audio portion of the detected signal is amplified by the audio channel in the monitor and fed through receptacles F/J2 (pins 3 and 4) and J205 (pins 14 and 15) to jack J201, which may be used by maintenance personnel to monitor the signal at the shelter.

b. The audio signal is applied from receptacle J201 through the deenergized contacts of tone-voice relay O 208, contacts of LOCAL-REMOTE switch S202 in REMOTE position, contacts of RING-TALK switch S201 in neutral position, and the deenergized contacts of relay O 201 to transformer T201. The signal is coupled through transformer T201 and terminal boards E201 and TB804 (terminals 1 and 2) to the telephone line which is connected to the remote control point. At the remote control point, the telephone line connects to terminal board E501 (terminals 1 and 2) and feeds the audio signal through transformer T501, the deenergized contacts of press-to-talk relay O 501, and the deenergized contacts of dial I 501 to receptacle J501. Sound-powered handset HS1 connects to receptacle J501 (pins 2 and 3) and enables the operator to hear the audio signal.

Section XXIX. INTERUNIT THEORY OF HANDSET INTERCOMMUNICATION CIRCUITS

217. General

An intercommunication circuit between the local and remote points is provided for the convenience of maintenance and operating personnel. This circuit consists of two sound-powered handsets and utilizes circuits within the C–1738/FRN–20 and C–1739/FRN–20.

218. Signaling Circuits

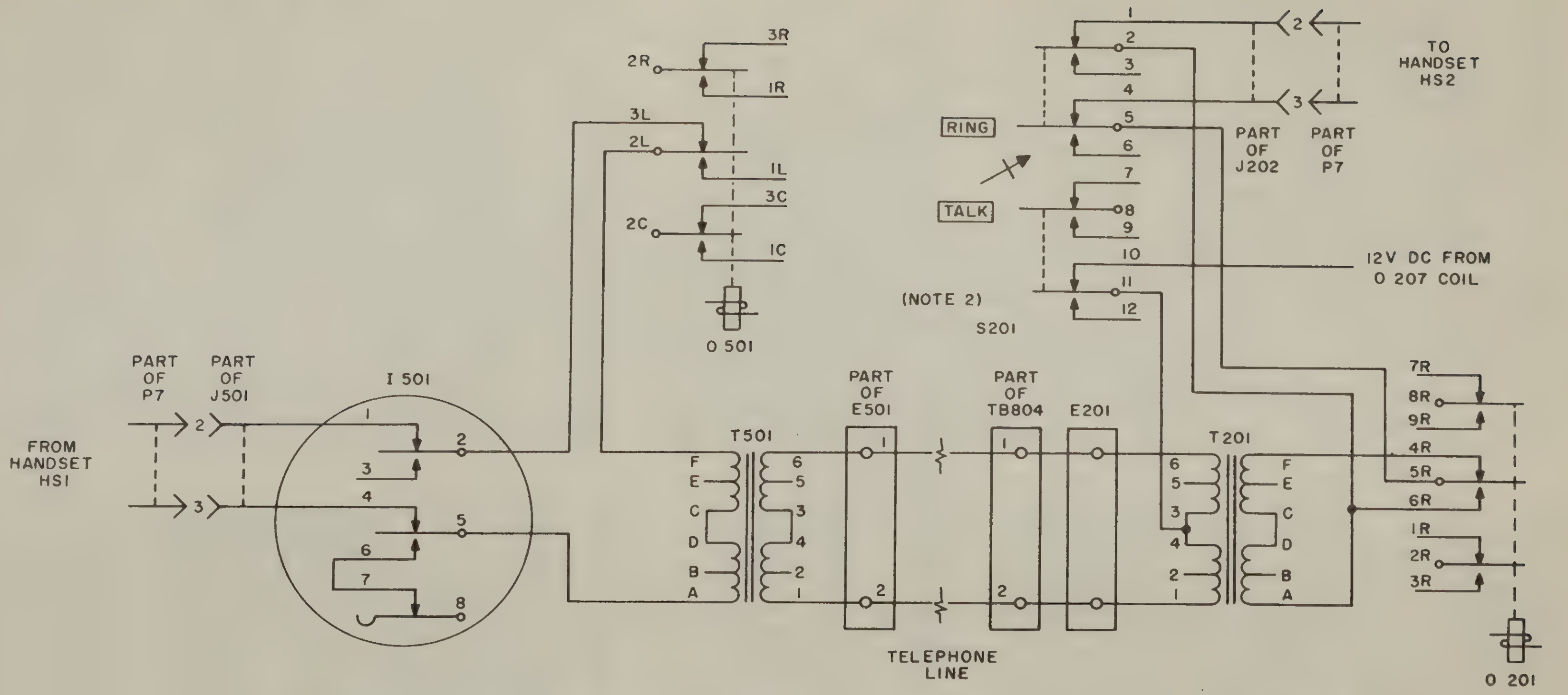
(fig. 160)

Maintenance personnel at the shelter may signal the operator any time the station is in warmup or omni condition by momentarily holding RING-TALK switch S201 in the RING position. This action interrupts the simplex voltage and causes the alarm buzzer in the C–1739/FRN–20 to sound. (For circuits of the buzzer, see monitoring and alarm circuits (par. 215 and fig. 159)). The operator at the remote control point may signal maintenance personnel at the shelter by dialing 5 several times. This action causes a relay in the C–1738/FRN–20 to click if the LOCAL-REMOTE switch is in LOCAL position. When the LOCAL-REMOTE switch is in the REMOTE position, dialing 5 from the remote point causes a pulsing relay and a minor switch to operate, and the clicking of these parts can be heard by the maintenance personnel and interpreted as a signal from the operator.

219. Voice Circuits

(fig. 160)

The voice signal developed in sound-powered handset HS2 is applied through receptacle J202, the contacts of RING-TALK switch S201 in the TALK position, and the deenergized contacts of relay O 201 to transformer T201. The voice signals are coupled through transformer T201, terminal boards E201 and TB804 (terminals 1 and 2) to the telephone line. The telephone line applies the signal through terminal board E501 (terminals 1 and 2), transformer T501, the deenergized contacts of relay O 501, and dial I 501 to receptacle J501. Handset HS1 connects to receptacle J501 to complete the intercommunication circuit.



LOCATION OF PARTS BY REFERENCE DESIGNATION

REFERENCE DESIGNATION	COMPONENT
201 – 299	RADIO SET CONTROL C-1738/FRN-20
501 – 599	RADIO SET CONTROL C-1739/FRN-20
801 – 899	ELECTRICAL EQUIPMENT CABINET CY-1897/FRN-22

NOTES

1. TABLE AT LEFT INDICATES LOCATION OF PARTS.
2. SWITCH S201 SHOWN IN THE TALK POSITION.

TM215-213

Figure 160. Handset intercommunication circuits, schematic diagram.

CHAPTER 3

PREVENTIVE MAINTENANCE AND LUBRICATION

Section I. PREVENTIVE MAINTENANCE

220. Equipment and Materials

a. Tools. Tool Equipment TE–41.

b. Materials.

(1) Cleaning Compound (Federal stock No. 7930–395–9542).

(2) Cleaning cloth.

(3) Fine sandpaper (#000).

221. DA Form 11–238

a. DA Form 11–238 is a preventive maintenance checklist used by the field repairman. Figures 161 and 162 show the form as it is used. References in the item blocks are to paragraphs that contain additional maintenance information. Items not applicable to this equipment are lined out. Items performed by the operator (par. 4 TM 11–5825–205–12) also are lined out. Instructions for use appear on the form.

b. The following information is supplementary to DA Form 11–238. The item numbers correspond to ITEM numbers on the form.

Item	Maintenance procedures
6	Remove all rust from components with sandpaper and touch up bare spots with paint.
7	With the exception of RF cables, repair any cuts in the insulation by covering them with rubber tape and then with friction tape. Replace RF cables which have cuts in the insulation. Replace or repair all broken cords and cables.
11	Six electrostatic air filters are used in the equipment. Remove and clean these filters at least once a month according to the procedure given in paragraph 222*b*.
25	Inspect the antenna and the AN/FRA–14 to see that all gaskets provide a good weatherproof seal.
26	Inspect the dipole antenna on the AN/FRA–14 for corrosion and loose connections. Check antenna mounting insulators for cracks or chipping.
27	Check the equipment for normal operation according to the chart (par. 229).

***Warning:* Obtain permission to disconnect all power before performing any of the following operations which may result in exposure to high voltages. After the power is turned off, some capacitors still retain voltages of dangerous potential. Before touching exposed electrical parts, short-circuit the part to ground. When maintenance is completed, reconnect the power and check for satisfactory operation.**

222. Cleaning Air Filters

Six electrostatic air filters are located in the equipment. One filter is used with each of the four cabinet blowers. Two filters are used with the shelter blower (figs. 6 and 7). The six filters must be cleaned at least once a month under normal conditions and more often when the equipment is operated in dry dusty areas. The procedure for removing, cleaning, and reinstalling the filters is outlined below.

a. Cabinet Blower Air Filters.

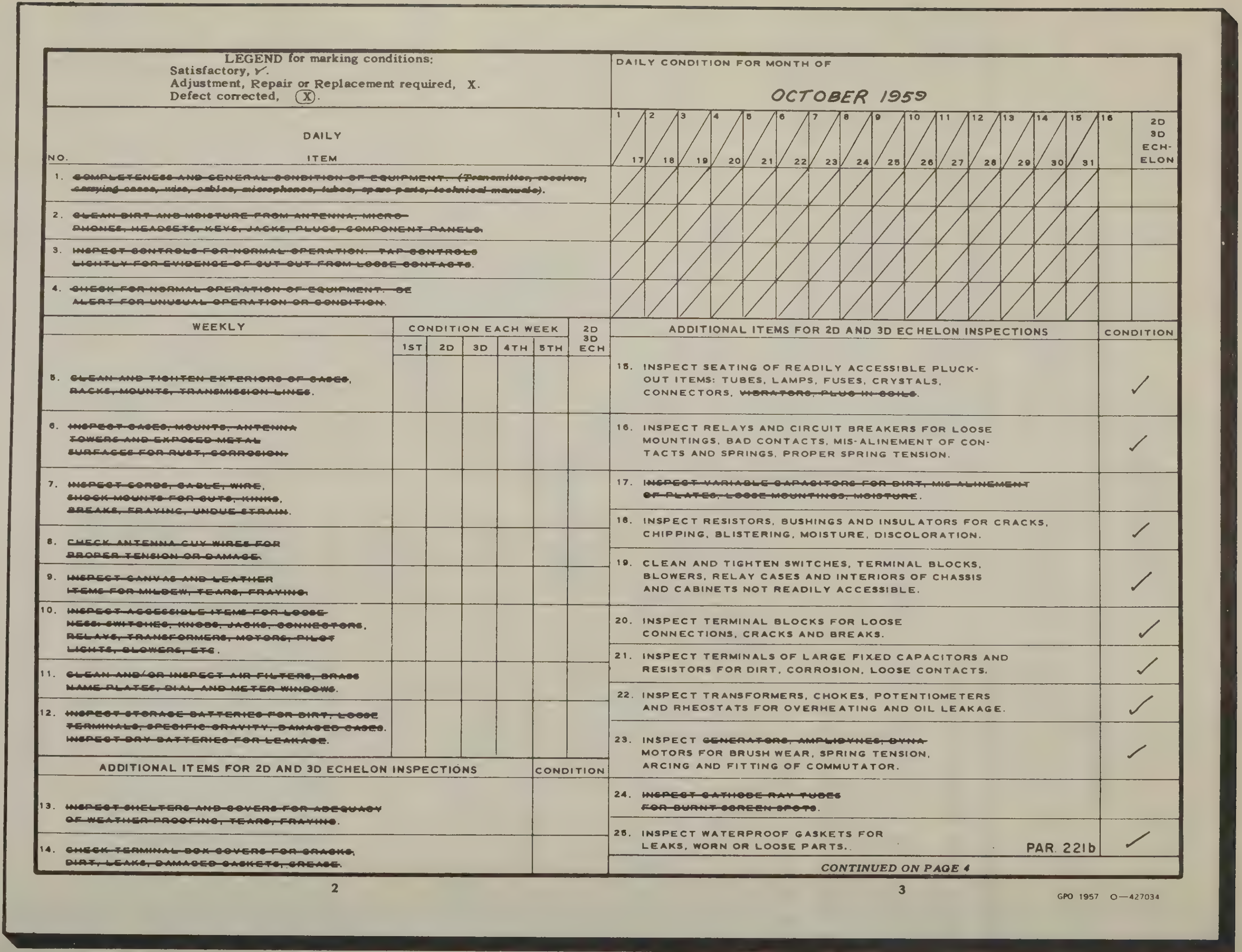
(1) Loosen the four quick-action fasteners which hold the cover on the blower housing (fig. 29) and remove the cover.

(2) Remove the air filter from the blower housing.

(3) Note the airflow arrows on the side of the filter. Before cleaning the filter, make permanent arrow marks on it to indicate direction of airflow.

(4) Wash the filter thoroughly in cool clean water. If necessary, use a detergent. Rinse in clear water. If a hose is available, pass a fine spray of water through the filter in a direction opposite to that of the airflow arrows on the side of the filter.

***Caution:* Do not direct a high velocity stream of water against the filter and do not disturb the normal distribution of the shredded material in the filter.**



LEGEND for marking conditions:
Satisfactory, ✓.
Adjustment, Repair or Replacement required, X.
Defect corrected, Ⓧ.

DAILY CONDITION FOR MONTH OF OCTOBER 1959

NO.	DAILY ITEM	1 / 17	2 / 18	3 / 19	4 / 20	5 / 21	6 / 22	7 / 23	8 / 24	9 / 25	10 / 26	11 / 27	12 / 28	13 / 29	14 / 30	15 / 31	16	2D 3D ECH-ELON
1.	~~COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT. (Transmitter, receiver, carrying cases, wire, cables, microphones, tubes, spare parts, technical manuals).~~																	
2.	~~CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONES, HEADSETS, KEYS, JACKS, PLUGS, COMPONENT PANELS.~~																	
3.	~~INSPECT CONTROLS FOR NORMAL OPERATION. TAP CONTROLS LIGHTLY FOR EVIDENCE OF CUT OUT FROM LOOSE CONTACTS.~~																	
4.	~~CHECK FOR NORMAL OPERATION OF EQUIPMENT. BE ALERT FOR UNUSUAL OPERATION OR CONDITION.~~																	

NO.	WEEKLY	CONDITION EACH WEEK					2D 3D ECH
		1ST	2D	3D	4TH	5TH	
5.	~~CLEAN AND TIGHTEN EXTERIORS OF CASES, RACKS, MOUNTS, TRANSMISSION LINES.~~						
6.	~~INSPECT CASES, MOUNTS, ANTENNA TOWERS AND EXPOSED METAL SURFACES FOR RUST, CORROSION.~~						
7.	~~INSPECT CORDS, CABLE, WIRE, SHOCK MOUNTS FOR CUTS, KINKS, BREAKS, FRAYING, UNDUE STRAIN.~~						
8.	~~CHECK ANTENNA GUY WIRES FOR PROPER TENSION OR DAMAGE.~~						
9.	~~INSPECT CANVAS AND LEATHER ITEMS FOR MILDEW, TEARS, FRAYING.~~						
10.	~~INSPECT ACCESSIBLE ITEMS FOR LOOSENESS: SWITCHES, KNOBS, JACKS, CONNECTORS, RELAYS, TRANSFORMERS, MOTORS, PILOT LIGHTS, BLOWERS, ETC.~~						
11.	~~CLEAN AND/OR INSPECT AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS.~~						
12.	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, SPECIFIC GRAVITY, DAMAGED CASES. INSPECT DRY BATTERIES FOR LEAKAGE.~~						

NO.	ADDITIONAL ITEMS FOR 2D AND 3D ECHELON INSPECTIONS	CONDITION
13.	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING, TEARS, FRAYING.~~	
14.	~~CHECK TERMINAL BOX COVERS FOR CRACKS, DIRT, LEAKS, DAMAGED GASKETS, GREASE.~~	

2

NO.	ADDITIONAL ITEMS FOR 2D AND 3D ECHELON INSPECTIONS	CONDITION
15.	INSPECT SEATING OF READILY ACCESSIBLE PLUCK-OUT ITEMS: TUBES, LAMPS, FUSES, CRYSTALS, CONNECTORS, ~~VIBRATORS, PLUG-IN COILS~~.	✓
16.	INSPECT RELAYS AND CIRCUIT BREAKERS FOR LOOSE MOUNTINGS, BAD CONTACTS, MIS-ALINEMENT OF CONTACTS AND SPRINGS, PROPER SPRING TENSION.	✓
17.	~~INSPECT VARIABLE CAPACITORS FOR DIRT, MIS-ALINEMENT OF PLATES, LOOSE MOUNTINGS, MOISTURE~~.	
18.	INSPECT RESISTORS, BUSHINGS AND INSULATORS FOR CRACKS, CHIPPING, BLISTERING, MOISTURE, DISCOLORATION.	✓
19.	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE.	✓
20.	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.	✓
21.	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR DIRT, CORROSION, LOOSE CONTACTS.	✓
22.	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS AND RHEOSTATS FOR OVERHEATING AND OIL LEAKAGE.	✓
23.	INSPECT ~~GENERATORS, AMPLIDYNES, DYNA-~~ MOTORS FOR BRUSH WEAR, SPRING TENSION, ARCING AND FITTING OF COMMUTATOR.	✓
24.	~~INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS~~.	
25.	INSPECT WATERPROOF GASKETS FOR LEAKS, WORN OR LOOSE PARTS. PAR. 221b	✓

CONTINUED ON PAGE 4

3

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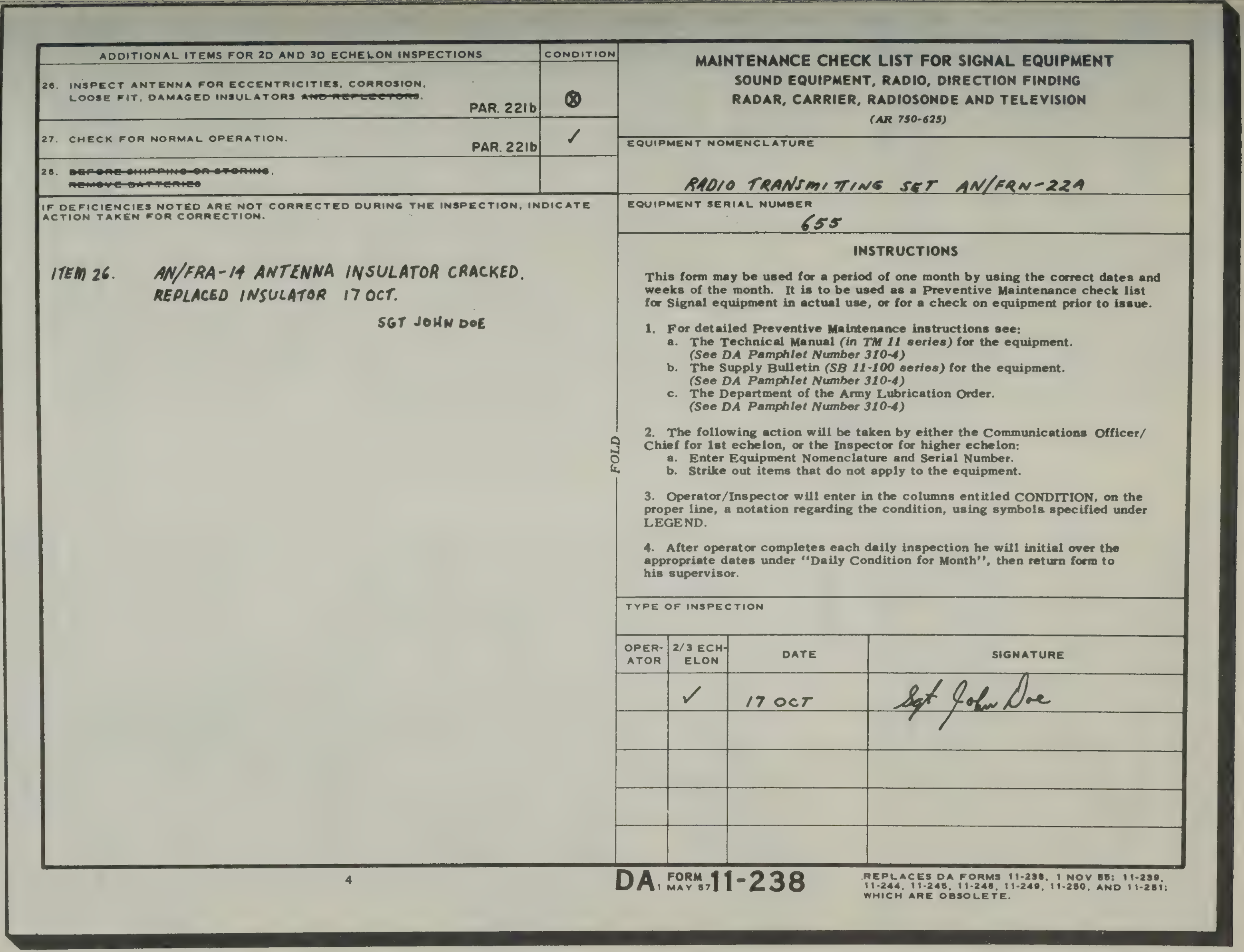
Figure 161. DA Form 11–238 (pages 2 and 3).



ADDITIONAL ITEMS FOR 2D AND 3D ECHELON INSPECTIONS		CONDITION
26. INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS ~~AND REFLECTORS~~.	PAR. 221b	⊗
27. CHECK FOR NORMAL OPERATION.	PAR. 221b	✓
28. ~~BEFORE SHIPPING OR STORING,~~ ~~REMOVE BATTERIES~~		

IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING THE INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

ITEM 26. AN/FRA-14 ANTENNA INSULATOR CRACKED.
REPLACED INSULATOR 17 OCT.

SGT JOHN DOE

4

FOLD

MAINTENANCE CHECK LIST FOR SIGNAL EQUIPMENT

SOUND EQUIPMENT, RADIO, DIRECTION FINDING
RADAR, CARRIER, RADIOSONDE AND TELEVISION
(AR 750-625)

EQUIPMENT NOMENCLATURE
RADIO TRANSMITTING SET AN/FRN-22A

EQUIPMENT SERIAL NUMBER
655

INSTRUCTIONS

This form may be used for a period of one month by using the correct dates and weeks of the month. It is to be used as a Preventive Maintenance check list for Signal equipment in actual use, or for a check on equipment prior to issue.

1. For detailed Preventive Maintenance instructions see:
   a. The Technical Manual *(in TM 11 series)* for the equipment. *(See DA Pamphlet Number 310-4)*
   b. The Supply Bulletin *(SB 11-100 series)* for the equipment. *(See DA Pamphlet Number 310-4)*
   c. The Department of the Army Lubrication Order. *(See DA Pamphlet Number 310-4)*

2. The following action will be taken by either the Communications Officer/Chief for 1st echelon, or the Inspector for higher echelon:
   a. Enter Equipment Nomenclature and Serial Number.
   b. Strike out items that do not apply to the equipment.

3. Operator/Inspector will enter in the columns entitled CONDITION, on the proper line, a notation regarding the condition, using symbols specified under LEGEND.

4. After operator completes each daily inspection he will initial over the appropriate dates under "Daily Condition for Month", then return form to his supervisor.

TYPE OF INSPECTION

OPERATOR	2/3 ECHELON	DATE	SIGNATURE
	✓	17 OCT	Sgt John Doe

DA FORM 11-238, 1 MAY 57

REPLACES DA FORMS 11-238, 1 NOV 55; 11-239, 11-244, 11-245, 11-248, 11-249, 11-250, AND 11-251; WHICH ARE OBSOLETE.

TM215-154

Figure 162. DA Form 11–238 (pages 1 and 4).

(5) Gently shake the water out of the filter. When the filter is thoroughly dry, replace it in the blower housing with the arrows on its side pointing toward the blower motor.

(6) Replace the cover on the blower housing and tighten the four quick-action fasteners.

b. Shelter Blower Air Filters.

(1) Loosen the two knurled thumbscrews which hold the rear panel of the blower housing in place (fig. 6). Grasp the rear panel firmly with both hands. Pull the panel outward to clear the lock hasp and pull downward to remove the top edge of the panel from under the flange on the blower cover.

(2) Remove the two air filters (fig. 7) from the blower housing. Follow instructions given in *a*(2) through (5) above.

(3) Gently shake the water out of the filters. When the filters are thoroughly dry, replace them in the blower housing with the arrows on their sides pointing toward the blower motor.

(4) Replace the rear panel of the blower housing. Tighten the two knurled thumbscrews to hold the panel in place.

Section II. LUBRICATION

223. Lubrication Points

a. General. Lubrication points for Radio Transmitting Set AN/FRN–22A are shown in figures 163 through 168. The symbol Q stands for a period of 3 months. The symbol S indicates every 6 months. A month interval consists of 30 days of normal 8-hour operation. If the equipment is operated more than 8 hours a day, the lubrication intervals will have to be adjusted to prevent excessive wear. For example, if the omnirange set is operated 16 hours a day instead of 8, lubrication periods have to be cut in half; semiannual (S) periods would become quarterly (Q) periods, and so on. The type of lubrication to be used, the lubrication interval, and special lubrication instructions are given directly on the respective illustrations. Additional instructions necessary to reach hidden lubrication points and additional lubrication instructions are given in *b* through *h* below.

b. Shelter Blower Motor (fig. 163).

Note. The shelter blower motor operates only when the temperature within the shelter rises above 85° F. The lubrication intervals should be adjusted on the basis of estimated operating time.

(1) Place circuit breaker K1015 (fig. 201) in the OFF position.

(2) Loosen the two knurled thumbscrews which hold the rear panel of the blower housing in place (fig. 6). Grasp the rear panel firmly with both hands. Pull the panel outward to clear the lock hasp and pull downward to remove the top edge of the panel from under the flange on the blower cover.

(3) Lubricate the motor according to lubrication instructions on figure 163. Use a clean cloth to wipe any excess oil from the exterior of the motor.

(4) Replace the rear panel of the blower housing. Tighten the two knurled thumbscrews to hold the panel in place.

(5) Place circuit breaker K1015 in the ON position.

c. Cabinet Blower Motors (fig. 167). A cabinet blower is located on the rear of each of the four electrical equipment cabinets in the shelter. Lubrication instructions for the cabinet blower motors are outlined below.

Note. Each cabinet blower motor operates only when the temperature in the cabinet rises above 90° F. The lubrication intervals should be adjusted on the basis of estimated operating time.

(1) Place circuit breaker K1015 (fig. 201) in the OFF position.

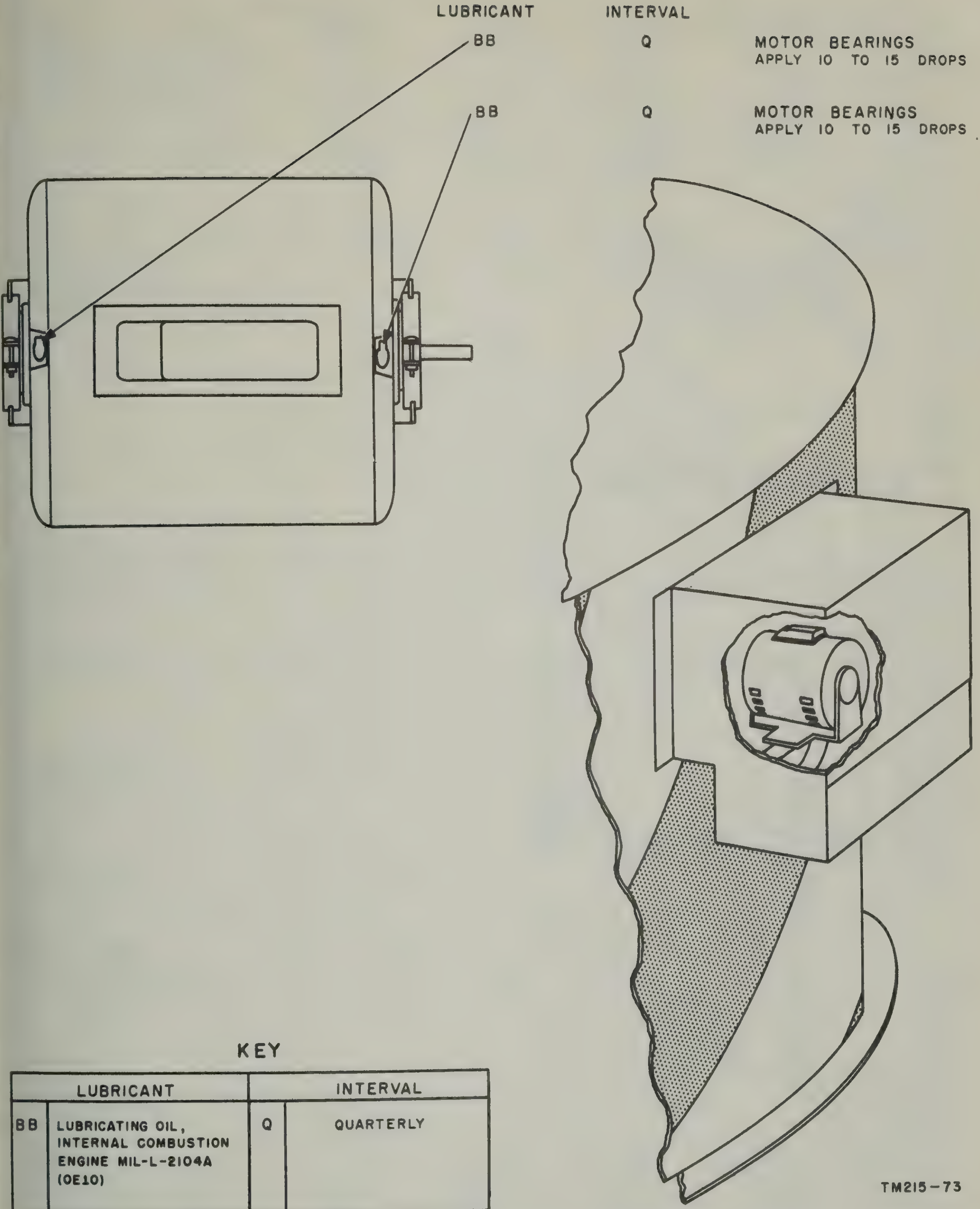
(2) Loosen the four quick-action fasteners which hold the cover on the blower housing (fig. 29) and remove the cover.

(3) Remove the air filter from the blower housing.

(4) Lubricate the motor according to lubrication instructions on figure 167. Use a clean cloth to wipe any excess oil from the exterior of the motor.

(5) Replace the air filter in the blower housing with the arrows on its side pointing toward the blower motor.

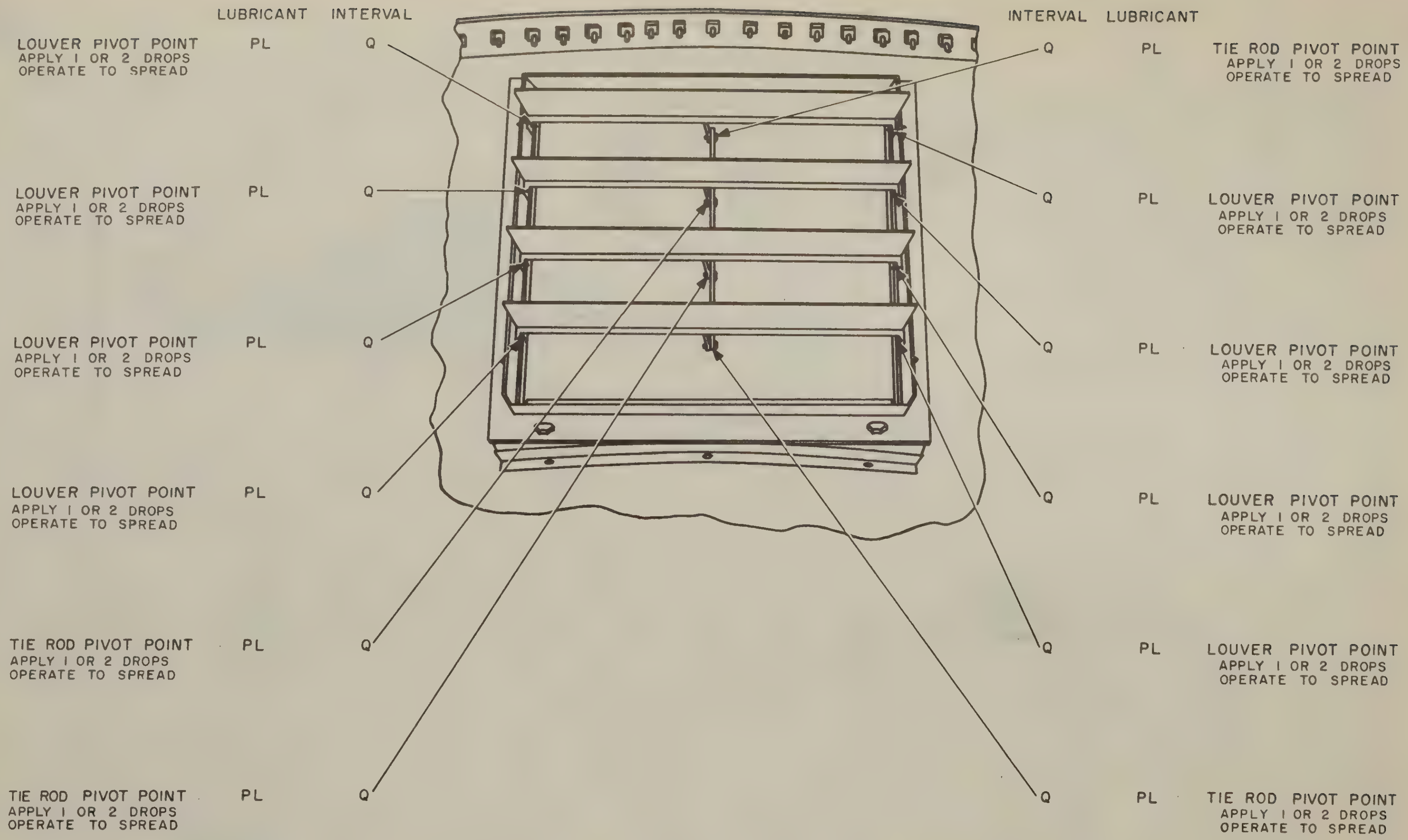
(6) Replace the cover on the blower housing and tighten the four quick-action fasteners.



KEY

LUBRICANT		INTERVAL	
BB	LUBRICATING OIL, INTERNAL COMBUSTION ENGINE MIL-L-2104A (OE10)	Q	QUARTERLY

Figure 163. Propeller Ventilating Fan HD-244/FRN-22, motor lubrication.



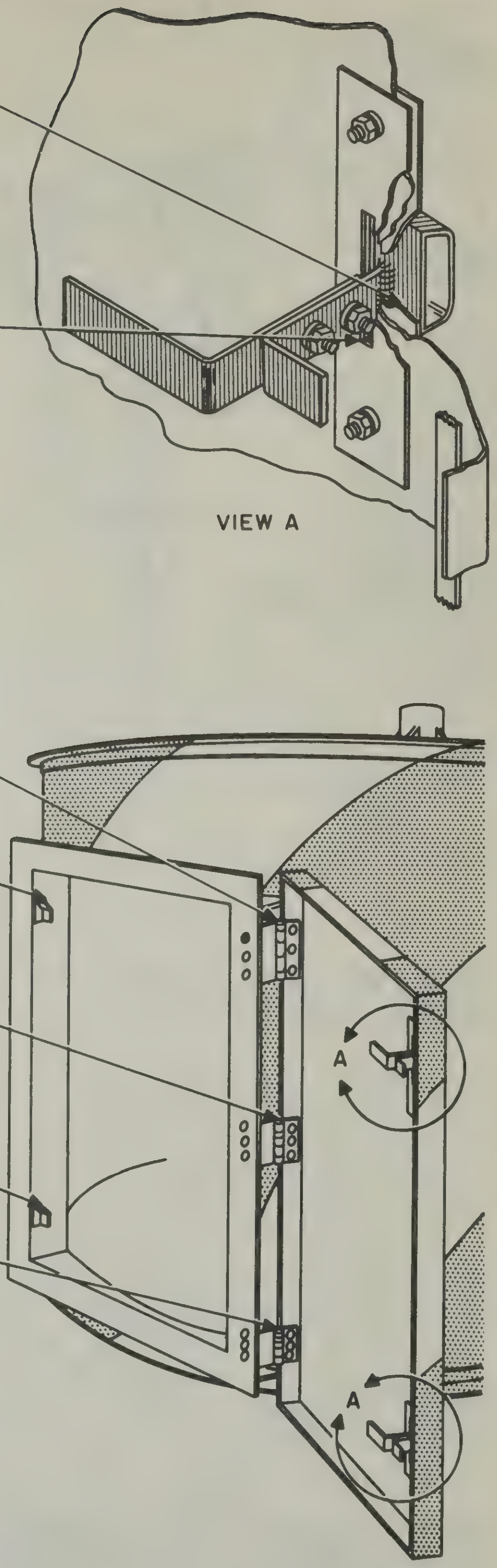
KEY

LUBRICANT		INTERVAL	
PL	LUBRICATING OIL, GENERAL PURPOSE, PRESERVATIVE MIL-L-644A (PL SPECIAL)	Q	QUARTERLY

TM215-74

Figure 164. Propeller Ventilating Fan HD–244/FRN–22, exhaust vent lubrication.

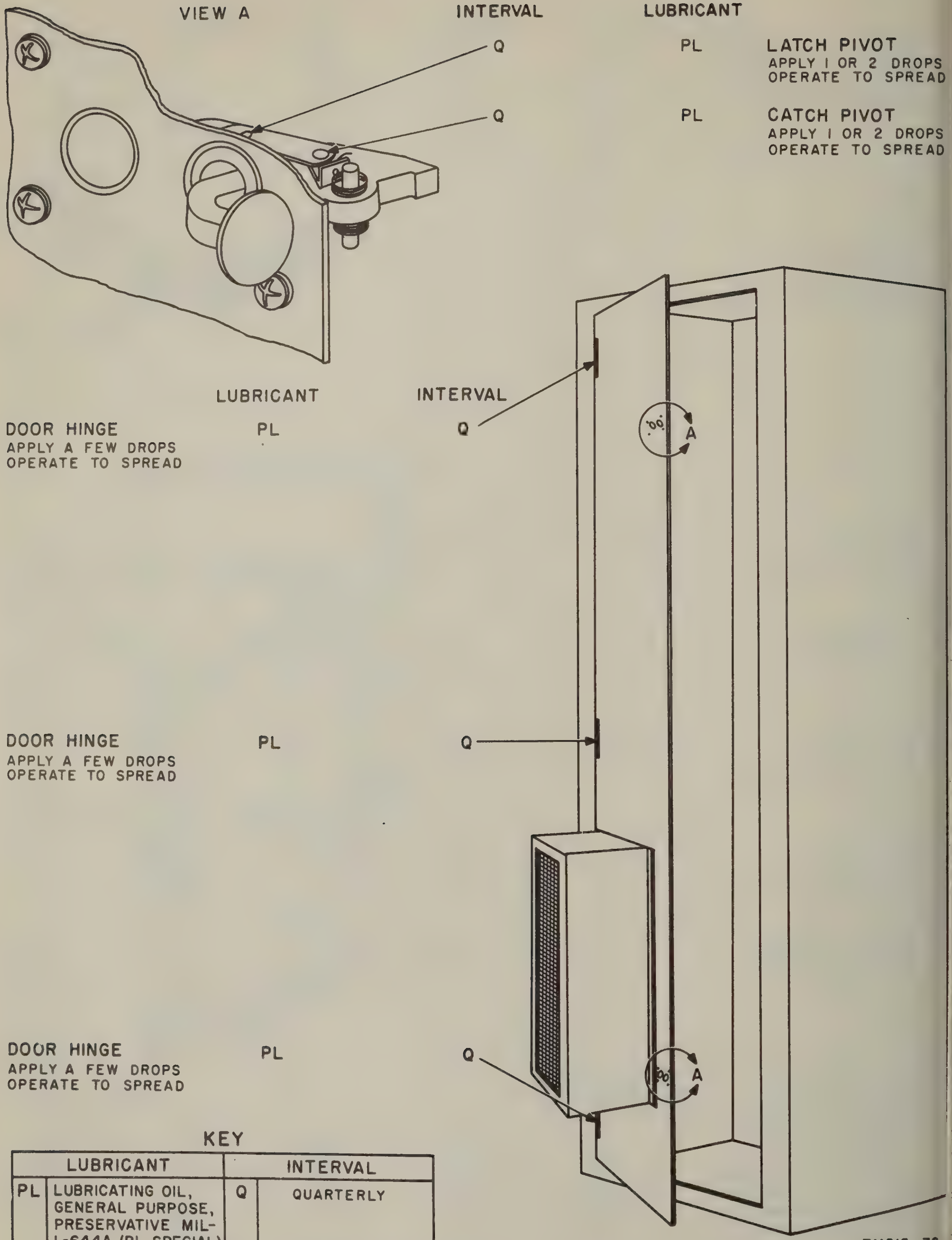
	LUBRICANT	INTERVAL
OUTSIDE LATCH HANDLE LUBRICATE MODERATELY BETWEEN LATCH HANDLE AND LATCH MOUNTING PLATE OPERATE TO SPREAD	GL	Q
LATCH MOUNTING PLATE SLOTS LUBRICATE MODERATELY OPERATE LATCH TO SPREAD	GL	Q
DOOR HINGE APPLY A FEW DROPS OPERATE TO SPREAD	PL	Q
LATCH HOOK LUBRICATE MODERATELY	GL	Q
DOOR HINGE APPLY A FEW DROPS OPERATE TO SPREAD	PL	Q
LATCH HOOK LUBRICATE MODERATELY	GL	Q
DOOR HINGE APPLY A FEW DROPS OPERATE TO SPREAD	PL	Q



KEY

LUBRICANT		INTERVAL	
PL	LUBRICATING OIL, GENERAL PURPOSE, PRESERVATIVE MIL-L-644A (PL SPECIAL)	Q	QUARTERLY
GL	GREASE, AIRCRAFT AND INSTRUMENT MIL-G-3278(GL)	Q	QUARTERLY

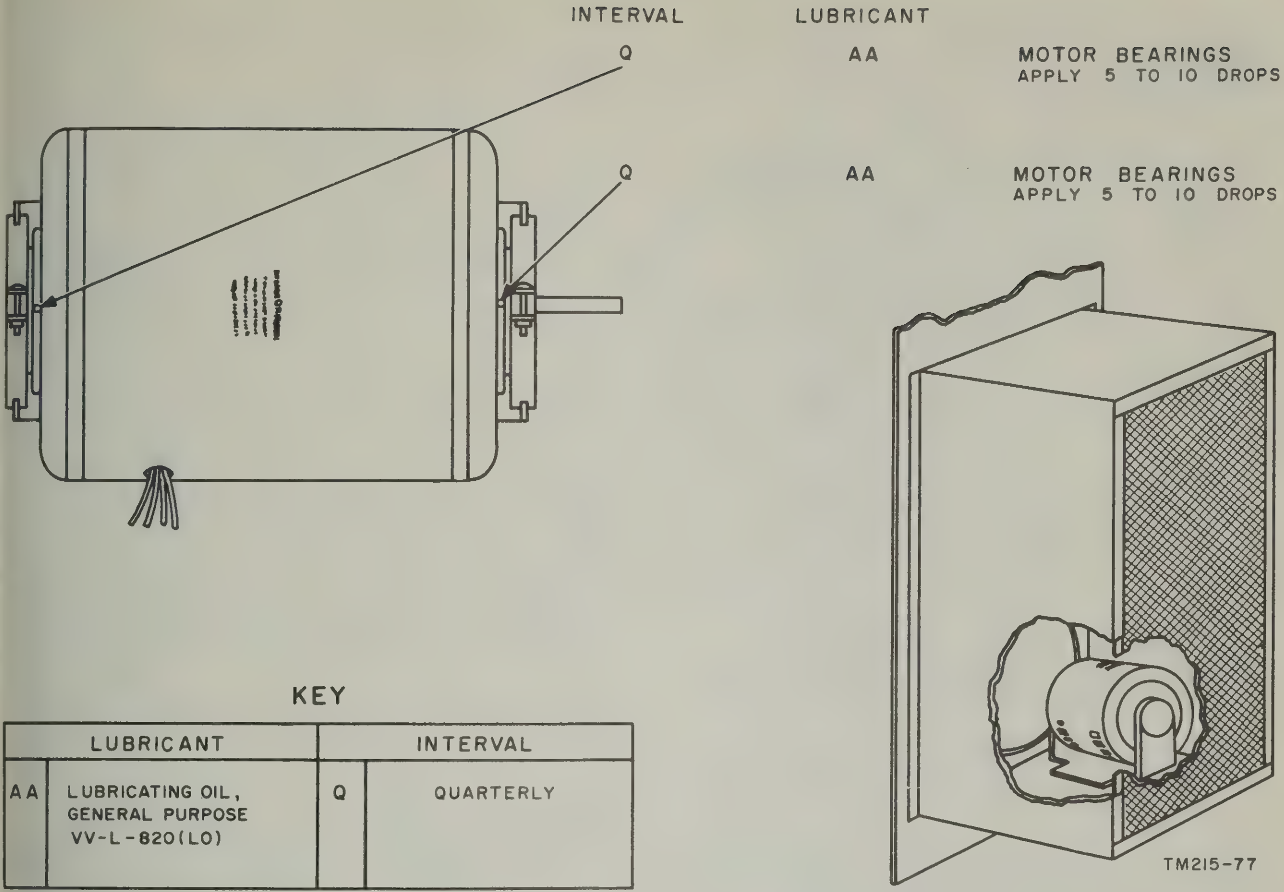
Figure 165. Electrical Equipment Shelter S-120/FRN-22, door lubrication.



KEY

LUBRICANT		INTERVAL	
PL	LUBRICATING OIL, GENERAL PURPOSE, PRESERVATIVE MIL-L-644A (PL SPECIAL)	Q	QUARTERLY

Figure 166. Electrical equipment cabinet, lubrication points.



LUBRICANT		INTERVAL	
AA	LUBRICATING OIL, GENERAL PURPOSE VV-L-820(LO)	Q	QUARTERLY

Figure 167. Cabinet blower motor, lubrication points.

(7) Place circuit breaker K1015 in the ON position.

d. Keyer Motors (fig. 168). One keyer is used with each of the two transmitting equipments. Lubricate the keyer motor of the idle transmitting equipment first. Place the idle transmitting equipment in operation while the second keyer motor is being lubricated. Lubrication instructions for the keyer motors are outlined below.

Warning: **Dangerous voltages exist in the cabinet in which the keyers are located. Be careful when removing the keyers from the cabinet.**

(1) Open the door of the CY–1897/FRN–22.
(2) Disconnect the three wires from terminal board TB501 at the rear of the idle keyer (fig. 16).
(3) Remove the ac plug from receptacle J501 on the keyer (fig. 16).
(4) Remove the trim strips from the front of the CY–1897/FRN–22 (fig. 11).
(5) Remove the four screws which mount the keyer in the cabinet and remove the keyer.
(6) Loosen the two knurled thumbscrews which hold the front panel of the keyer in place and remove the front panel.
(7) Lubricate the motor through the hole in the top of the chassis according to lubrication instructions on figure 168.
(8) Replace the front panel of the keyer and tighten the two knurled thumbscrews.
(9) Mount the keyer in the CY–1897/FRN–22 with four screws.
(10) Replace the trim strips on the front of the CY–1897/FRN–22.
(11) Insert the ac plug in receptacle J501 on the keyer (fig. 16).
(12) Connect the three wires to terminal board TB501 on the keyer (fig. 16).
(13) Close the door of the CY–1897/FRN–22.

e. Minor Switches. Two minor switches are

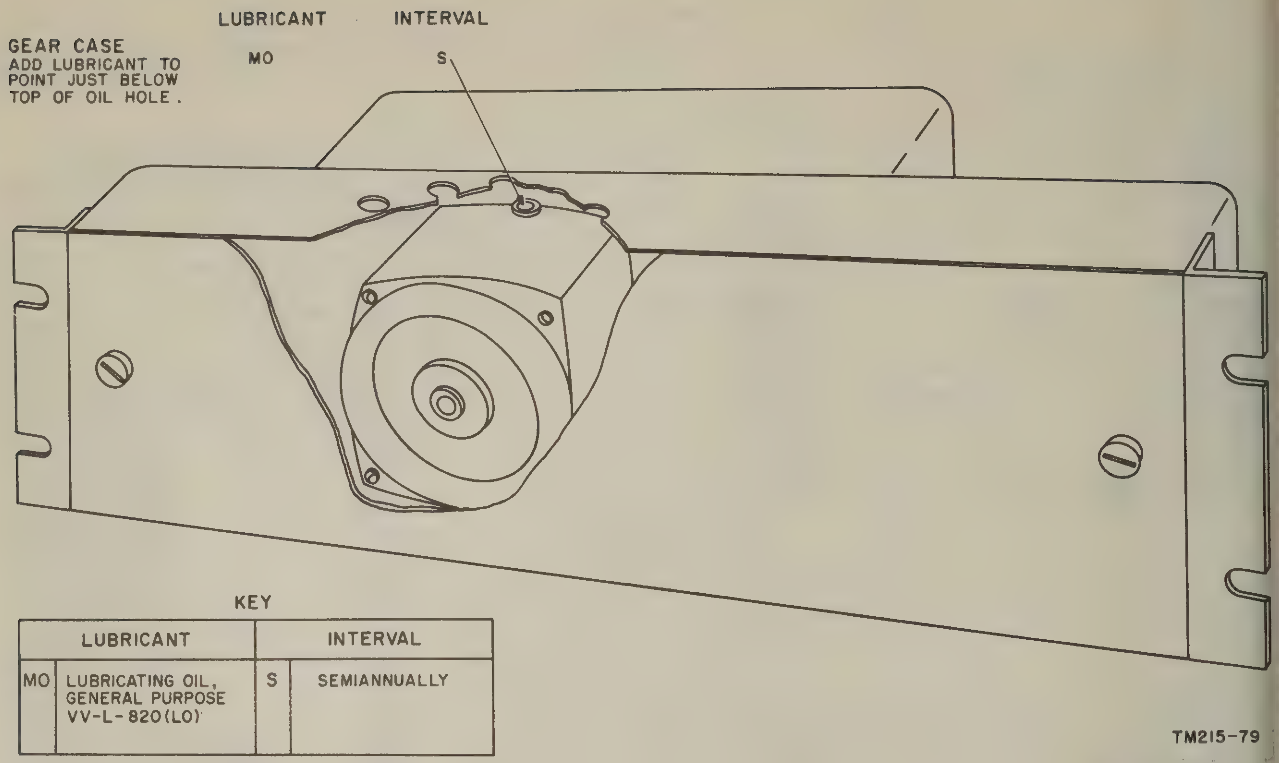

GEAR CASE
ADD LUBRICANT TO POINT JUST BELOW TOP OF OIL HOLE.
LUBRICANT
INTERVAL
MO
S
KEY
LUBRICANT
INTERVAL
MO
LUBRICATING OIL, GENERAL PURPOSE VV-L-820(LO)
S
SEMIANNUALLY
TM215-79

Figure 168. Keyer KY–175/FRN, motor lubrication.

used in the equipment. Minor switch K201 is located in the C–1738/FRN–20. Minor switch K605 is located in the C–1840/FRN–22. Both components on which the minor switches are located are mounted in the CY–1897/FRN–22. Lubrication instructions for both minor switches are outlined below.

Note. Before starting the lubrication procedures outlined below, refer to TM 11–2103 for information on lubrication intervals.

***Warning:* Dangerous voltages exist in the CY–1897/FRN–22. Do not touch cabinet terminal board TB805 or any portion of the voltage regulator.**

(1) Place circuit breakers K1003 and K1004 in the OFF position (fig. 201).

(2) Open the door at the rear of the CY–1897/FRN–22.

(3) Remove the two screws that hold the dust cover on the rear of the C–1840/FRN–22 (fig. 28). Remove the dust cover.

(4) Remove the two knurled thumbnuts that hold the dust cover on the rear of the C–1738/FRN–20. Remove the dust cover.

(5) Lubricate the minor switches according to lubrication instructions in TM 11–2103.

(6) Replace the dust cover on the C–1840/FRN–22 and tighten the cover screws.

(7) Replace the dust cover on the C–1738/FRN–20 and tighten the knurled thumbnuts.

(8) Close the door of the cabinet.

(9) Set circuit breakers K1003 and K1004 to the ON position.

f. Telephone Dials. Two telephone dials are used in the equipment: One dial is located on the remote control unit (fig. 48); the other dial is located on the C–1738/FRN–20. Lubrication instructions for telephone dials are outlined below.

Note. Before starting the lubrication procedures outlined below, refer to TM 11–2103 for information on lubrication intervals.

(1) At the remote control point, disconnect the power cable for the remote control unit and the AM–1247/FRN–20 from the 115-volt ac power source.

(2) Within the shelter, place circuit breakers K1003 and K1004 in the OFF position (fig. 201).

(3) The telephone dial on the C–1738/FRN–20 should be lubricated first. Loosen the two knurled thumbnuts that hold the front panel of the C–1738/FRN–20 in place and pull the front panel away from the unit.

(4) Lubricate the telephone dial according to lubrication instructions in TM 11–2103.

(5) Replace the front panel of the C–1738/FRN–20 and tighten the two knurled thumbscrews.

(6) Place circuit breakers K1003 and K1004 in the ON position.

(7) Loosen the two knurled thumbscrews that hold the front panel of the remote control unit (fig. 222) in place. Pull the front panel away from the unit.

(8) Lubricate the telephone dial according to lubrication instructions in TM 11–2103.

(9) Replace the front panel of the remote control unit and tighten the two knurled thumbscrews.

(10) Connect the power cable for the remote control unit and the AM–1247/FRN–20 to the 115-volt ac power source.

g. Goniometer Motors (fig. 228). Electrical Goniometer GO–12/FRN–20, serial numbers 604 and below, have motors which require lubrication. Goniometers with serial numbers 605 and above have sealed motor bearings and require no lubrication.

***Warning:* Dangerous voltages exist in the CY–1899/FRN–22. Deenergize the cabinet before removal of the goniometer chassis.**

(1) Disconnect the goniometer plugs and cables (fig. 16) and remove the chassis from the cabinet (par. 357).

(2) Disconnect the motor wiring (fig. 30, 228) and remove the four sets of mounting hardware holding the motor to the chassis. Remove the belt and the motor.

(3) Loosen the two pulley setscrews and remove the pulley. Remove the eight cover screws, cover plates, spacers, and shims; be sure to keep parts associated with each endbell in correct sequence.

(4) Clean bearings carefully with a brush and cleaning compound. Do not permit solvent to flow into the motor Dry with low pressure clean dry air.

(5) Fill the bearing only (not the endbell) annually with Grease, Aircraft and Instrument, MIL–G–3278. Reassemble the shims, spacers, and cover plates.

(6) Tighten the eight cover screws. Operate the motor to see that the armature rotates freely.

(7) Mount the motor on the goniometer chassis and adjust the belt tension as instructed in paragraph 41.

(8) Reconnect motor wires and reinstall the goniometer chassis in the CY–1899/FRN–22.

(9) Reconnect the goniometer chassis cables (fig. 16) and energize the equipment to test the motor operation.

h. Items Lubricated by Manufacturer. Regulator motor B1, a part of Voltage Regulator CN–358/FRN–22, (fig. 269) and the goniometer and FM capacitor shaft bearings, part of Electrical Goniometer GO–12/FRN–20, have sealed bearings and require no additional lubrication. Sequential timer S601 (fig. 251), a part of Radio Set Transfer Control C–1840/FRN–22, has oilite bearings and requires no additional lubrication. The keyer gears (fig. 235, a part of Keyer KY–175/FRN), have an electrofilm finish and require no additional lubrication.

CHAPTER 4

TROUBLESHOOTING

Section I. GENERAL TROUBLESHOOTING INFORMATION

***Warning:* Extremely high voltages are present in all cabinets of the omnirange set at all times. Take adequate precautions during all troubleshooting to avoid contact with the cabinet framework and exposed terminals, tube caps, and rf inductors. Use dry, insulated tools and test prods for all measurements. Make a thorough check to insure that all switches and circuit breakers are in the off position before entering a cabinet. Discharge all capacitors and points which require personal contact, so that no voltage exists. *If there is any doubt, shut down the omnirange set and turn off all circuit breakers.* Prior to applying power, perform a thorough visual inspection to avoid shorts that could be caused by tools, wire clippings, wrong connections, and excess solder. Keep all station personnel well informed of existing conditions during troubleshooting. Safety-wire the circuit breakers to OFF or remove the fuses when leaving the equipment site in a nonoperating condition.**

224. Visual Inspection of AN/FRN–22A

Note. To observe the operation of components within the equipment cabinets, insert interlock jumper plugs into the female interlock switch contacts, located in the upper right-hand corner of the door opening. One interlock switch on each cabinet is for the cabinet heaters and one is for the cabinet blower. When inserting interlock jumper plugs, be sure to remain clear of the cabinet blower.

Troubles are sometimes caused by defects that are easy to see. Such defects are listed in *a* through *n* below. Check as many of these as may apply to the troubleshooting problem before using more involved procedures.

a. Tripped circuit breakers.

b. Open or defective interlock switches on cabinet doors and behind component front panels.

c. Blown fuses.

d. Unlighted tube filaments or improper seating of tubes.

e. Loose connections to terminal boards.

f. Improper seating of cable connectors.

g. Worn or broken cables, cords, and wiring harnesses.

h. Dirty or burned relay contacts.

i. Dirty or defective switches.

j. Cracked or charred resistors.

k. Bulging or leaking capacitors.

l. Blistering of paint or other signs of overheating on transformers, chokes, and motor cases.

m. Discoloration of the insulation on wires, relay armature windings, and windings of chokes and transformers. Under heavy overload, it is possible for some wires to overheat and result in no visible evidence other than a slight discoloration of the insulation surrounding the wire.

n. Worn or broken goniometer drive belt.

225. General Instructions

Troubleshooting at field and depot maintenance levels includes all the techniques outlined for organizational maintenance and any special or additional techniques required to isolate a defective part. The field and depot maintenance procedures are not complete in themselves but supplement other procedures described previously. The systematic troubleshooting procedure, which begins with the operational and sectionalization checks at organizational level, must be completed by sectionalizing, localizing, and isolating techniques. When the omnirange set is completely shut down because of undetermined trouble, it will be necessary to perform all the tests contained in paragraph 229 to determine whether the troubleshooting chart in paragraphs 231 through 255 will help to locate the defective unit

Omit the steps given in paragraph 229 only when defective operation indicates that continued operation will damage the equipment; instead, proceed with the test steps for the other equipment to determine its condition. If the trouble reported by organizational personnel indicates trouble due to defects common to both equipments, No. 1 and No. 2, use the procedures given in paragraphs 231 through 237 or paragraphs 248 through 255. When one equipment is performing the normal functions of the omnirange set, apply the procedures given in paragraphs 238 through 247 to the defective equipment. The completion of procedures indicated in paragraphs 231 through 255 will localize the trouble to a defective component. The remaining sections of this chapter are provided for individual unit troubleshooting by field and/or depot maintenance personnel, to isolate the defective part of a specific component.

226. Troubleshooting Procedures for AN/FRN-22A

a. General. The first step in servicing a defective omnirange set is to sectionalize the fault. Sectionalization means tracing the fault to a major component or group of components responsible for abnormal operation. The second step is to localize the fault. Localization means tracing the fault to a defective unit. The third step is isolation, which means troubleshooting to determine the defective part within a stage. Visual inspection frequently isolates the trouble immediately, because burned-out resistors or arcing and shorted transformers provide sight, smell, and hearing indications. Generally the trouble must be located by using test equipment and, in some cases, by equipment or part substitution.

b. Sectionalization. Sectionalization is the procedure by which a trouble is traced to a particular equipment or circuit such as: equipment No. 1 or No. 2, ac distribution, control, interlock, transmitter or RF carrier, modulating, antenna and phasing, or monitor and alarm circuits. The tests listed below are arranged to indicate the best order to use in sectionalized troubleshooting.

(1) *Prefailure reports.* Contact the operator and organizational maintenance personnel for a full report on equipment operation at the time of the failure. Note any peculiarities which may have been noticed just prior to the failure. Check the procedures completed by organizational personnel for possible clues to the trouble. Carefully observe any information contained on tags and report forms.

(2) *Visual inspection.* The purpose of visual inspection is to detect faults quickly without test equipment and to prevent further damage to equipment by the application of power when shorts and overheated parts exist. When evidence indicates a short or overheated condition, make a continuity check immediately and correct the fault before applying power.

(3) *Operational tests.* Operational tests apply to all sections of this chapter and must include an overall visual inspection immediately after power application. Each operational step of the charts will produce a normal indication if there is no defect present, and the absence of the normal indication immediately provides a clue to the defective section. The charts provided in paragraphs 231 through 247 are based upon proceeding through operational functions until the defective section is located.

c. Localization. The tests listed below are used to follow the trouble to the specific unit or stage which is causing faulty operation.

(1) *Signal tracing.* Signal tracing includes the tracing, unit by unit or stage by stage, of a signal voltage from the input of one unit or stage to the output of the same unit or stage to locate the point of failure. If a normal signal is present at the input but fails to meet requirements at the output, the unit or stage is defective.

(2) *Voltage and resistance measurements.* Voltage and resistance measurements on the interconnecting wiring between components further help to localize troubles in relation to components. The lack of signal between components may be caused by shorted or open interconnecting cables.

(3) *Unit substitution.* In emergencies and when permitted by the officer in charge,

the substitution of components of known quality will expedite getting the omnirange set into operation. This procedure should be used only when voltage and resistance measurements positively show that there are no external faults that will damage the substitute.

d. Isolation. Isolation of the component part of a component which is defective is outlined below.

(1) *Signal tracing.* Further tracing of signal voltages within the unit is accomplished through use of test setups on the bench. The application of a signal to the input permits following the signal until the defective part is located. This procedure may be used while the component is connected in the equipment; however, because of space limitations it normally will be done on the bench.

(2) *Voltage and resistance measurements.* Use voltage and resistance measurements to locate the defective part and establish the type of part defect. Certain parts which become defective may weaken or damage other parts. A shorted capacitor can overload an associated resistor or inductor, and an open resistor or inductor may cause the voltage maximum of other parts to be exceeded. Normal values of voltage and resistance are listed in charts and figures as aids in troubleshooting.

(3) *Stage-gain chart.* Stage-gain charts are provided, where applicable, to assist in the isolation of weak signal troubles and minor losses in a stage. Procedures for performing stage-gain checks are referenced in the chart.

(4) *Troubleshooting chart.* Troubles are listed in these charts in a sequence that will isolate a trouble in large sections first and work down to the specific part.

(5) *Signal substitution.* Signal substitution is used to isolate the defective stage when circuit characteristics prevent signal tracing or stage-gain checks. Complete information for the use of a signal generator, audio oscillator, and oscilloscope, as applicable, are contained in the sections as required.

e. Locating Intermittent Troubles. During all troubleshooting procedures, the possibility of intermittent troubles should not be overlooked. If present, this type of trouble often may be made to reappear by tapping or jarring the equipment. Check all wiring, terminal board connections, and connector plugs for mechanical and electrical condition. Improperly installed terminal lugs and poor solder connections are some of the most frequent causes of intermittents.

227. Tube Testing and Replacement

When trouble occurs, make a visual inspection of the equipment (par. 224) and then use the preliminary troubleshooting charts (par. 229) to localize the trouble. If a tube tester is available, proceed as outlined in *a* below. If no tube tester is available, proceed as outlined in *b* or *c* below; if these procedures fail to clear the trouble, notify a higher echelon repairman.

Cautions:

1. Do not rock or rotate a tube when removing it from a socket; pull it straight out with a tube puller.

2. When a tube is replaced, readjust or retune the associated circuit. Refer to paragraphs 30 through 61 to find the correct adjustment or tuning procedure.

Notes.

1. Do not use nonpreferred type tubes in place of preferred types. For example, do not use a 6AU6 (nonpreferred) to replace a 6AU6WA (preferred).

2. Paragraph 228 lists the *nonpreferred* type tubes used in this equipment, that *can be replaced* by the corresponding *preferred* type tubes.

a. Using Tube Tester.

(1) Remove and test *one* tube at a time. If it is necessary to remove more than one tube at a time, label each one so that it can be replaced, if satisfactory, in its original socket.

(2) Replace a tube only when there is an obvious defect, such as a broken glass envelope, open filament, broken lead or connecting prong, or when a test in a tube tester or other equipment shows the tube to be defective.

(3) Do not discard a tube merely because it tests *on or near* the minimum test limit of the tube tester. Some new tubes test near the low end of the acceptable range of the tube specification. These

tubes provide satisfactory service over a long period of time, even though they remain at, or near, this low limit value.

(4) Do not discard a tube merely because it has been in use for a specified length of time. *Satisfactory operation in a circuit is final proof of tube quality.*

b. Single-tube Substitution Method.

(1) Substitute a new tube for one of the suspected original tubes. If the equipment continues to be inoperative, replace the new tube with the original. Similarly, check each original tube suspected, one at a time, until the defective tube is located and the equipment becomes operative. Discard the last original tube removed from the equipment. DO NOT LEAVE A NEW TUBE IN A SOCKET IF THE EQUIPMENT OPERATES SATISFACTORILY WITH THE ORIGINAL TUBE.

(2) If this method of tube substitution does not correct the trouble, try the method described in *c* below.

c. Multitube Substitution Method. If two or more tubes are defective in a piece of equipment, it is necessary to install new tubes, one at a time, until the equipment becomes operative. Proceed as follows:

(1) Remove one of the suspected original tubes. Install a new tube. If the equipment is still inoperative, leave the new tube in place and remove the next suspected original tube. Install another new tube. Mark the original tubes with the socket number from which they were removed. Continue this procedure until the equipment becomes operative. The last original tube removed is defective and should be discarded.

(2) To determine whether another original tube is defective, return one of them to its original socket. If there is no noticeable difference in performance, leave the original tube in the equipment. In the same way, return the remaining original tubes to their sockets, one at a time. If equipment failure occurs, or performance suffers, discard the last original tube installed. DO NOT LEAVE A NEW TUBE IN A SOCKET IF THE EQUIPMENT OPERATES SATISFACTORILY WITH THE ORIGINAL TUBE.

228. Preferred Type Tubes

The chart below lists the authorized preferred type tubes that can be used to replace the corresponding nonpreferred type.

Nonpreferred-type tube	Preferred-type tube
6189/12AU7WA	5814A
6BA6	5749/6BA6W
807	5933
6100/6C4WA	6C4W
6681/12AX7	5751

229. Preliminary Tests for Inoperative Radio Transmitting Set AN/FRN–22A

The information in this paragraph will help to determine whether one equipment can be placed on the air as a navigational station while the other equipment is being repaired. If the fault exists in the circuits common to both equipments (control, antenna, monitoring and alarm circuits, or voice-modulating signal circuits), the station must be repaired from an out-of-service condition. If the fault exists in components used in one equipment only, however, the other equipment should be placed in operation while troubleshooting the faulty equipment in accordance with paragraphs 238 through 247.

a. Determining Procedure. Perform the procedures given in this paragraph to determine whether the troubleshooting procedures in paragraphs 231 through 255 will be used. Perform a complete visual inspection of all the cabinets in accordance with instructions in paragraph 224.

b. Preliminary Tests. Use the charts below when performing preliminary tests before starting the actual troubleshooting procedures. The charts give the locations at which the actions are to be performed. Use the omnirange site chart (*c* below) first. After the locations for the omnirange site have been checked and any abnormal indications corrected, use the remote control point chart (*d* below). To simplify the procedures, information for checking transmitting equipment No. 1 and transmitting equipment No. 2 has been combined in both charts.

Unless otherwise indicated, this information applies equally to both transmitting equipments. Correct any defective units by following the procedures given in the appropriate section of chapter 5.

c. Chart for Omnirange Site.

Step	Component	Action	Normal indications	Corrective measures
1	Antenna pedestal (fig. 201).	Set circuit breaker K1001 to ON.		
2	Antenna pedestal	Set circuit breaker K1015 to ON.	When the temperature in shelter is above 85° F., the shelter blower will operate.	Check fuse F1001 (fig. 8). Check wiring from antenna pedestal to shelter blower. Check thermostat S1003 (fig. 8).
			When the temperature in any of the four electrical equipment cabinets is above 90° F., the blower in that cabinet will operate.	Check fuse F1 on motor mounting bracket (fig. 29). Check seating of blower motor power plug (fig. 35). Check blower thermostat in cabinet (fig. 225).
			When the temperature in any of the four electrical equipment cabinets is below 55° F., the heaters in that cabinet will operate.	Check wiring to heater elements (fig. 16). Check heater thermostat in cabinet (fig. 225).
3	Voltage regulator	Set circuit breaker K1 to ON.	Red pilot lamp lights and ac meter reads 230 volts.	If pilot lamp does not light and there is no indication on meter, check fuses F1 and F2 (fig. 269) and wiring from antenna pedestal to voltage regulator (fig. 16). If pilot lamp does not light but meter reading is normal, check fuse F4 and pilot lamp (fig. 268). If pilot lamp lights but meter reading is abnormal, adjust voltage regulator (par. 34).
4	Antenna pedestal	Set circuit breaker K1002 to ON.	Body of antenna is warm to the touch after sufficient time for antenna heaters to warm up.	Check wiring from antenna pedestal to antenna heaters (fig. 16).
5	Antenna pedestal	Set circuit breaker K1003 to ON.		
6	Antenna pedestal	Set circuit breaker K1004 to ON.		
7	Monitor (fig. 32)	Set ON-OFF switch to ON.	Green POWER pilot lamp lights.	Check fuse F1. Check seating of power cable plugs. Check pilot lamp.
			Three red pilot lamps, designated ALARMS, light.	Check pilot lamps. Check contacts on relays RY2, RY3, and RY4 (fig. 220(4)).
8	Antenna pedestal	Set circuit breaker K1005 to ON.	Shelter lights light	Check light bulbs.
9	Antenna pedestal	Set circuit breaker K1006 to ON.	Obstruction lights light	Check light bulbs in obstruction light. Check wiring from antenna pedestal to obstruction light (fig. 16).

Step	Component	Action	Normal indications	Corrective measures
10	Antenna pedestal	Set circuit breaker K1007 to ON.	Convenience outlets are supplied with 115 volts ac.	Check wiring to convenience outlets.
11	Antenna pedestal	Set circuit breaker K1011 to ON. (Transmitting equipment No. 1 only).		
12	Antenna pedestal	Set circuit breaker K1012 to ON. (Transmitting equipment No. 2 only).		
13	PP–1331/FRN–20 (fig. 242).	Set ON-OFF switch to ON.		
14	C–1738/FRN–20 (fig. 13).	Set LOCAL-REMOTE switch to the LOCAL position.		
15	C–1738/FRN–20	Dial 9 for transmitting equipment No. 1 or dial 7 for transmitting equipment No. 2.	Minor switch K201 (fig. 247) makes clicking sound as it operates the number of times corresponding to number dialed.	Check fuses F1201 and F1202 on the PP–1415/FRN–22 (fig. 245). Check seating of power cable plugs on the PP–1415/FRN–22 (fig. 16). Check TB1202 on the PP–1415/FRN–22. Check the seating of plugs P803 and P804 on the C–1738/FRN–20.
			Antenna relays on antenna pedestal make loud click as they operate. (Transmitting equipment No. 1 only).	Check antenna relays. Check the wiring at terminals 3 and 4 of TB801 and terminals 9 and 10 of TB802 in the CY–1897/FRN–22 (fig. 225(1)).
16	Meter panel (fig. 232)	Turn LINE switch to EQUIPMENT NO. 1 or EQUIPMENT NO. 2.		
17	C–1738/FRN–20	Dial 8 for transmitting equipment No. 1 or 6 for transmitting equipment No. 2.	Green EQUIPMENT NO. 1 pilot lamp lights.	Check pilot lamp.
			On the meter panel, VOLTS meter indicates 115 volts ac and FREQUENCY meter indicates the frequency of the main ac power supplied to the omnirange set.	Check the seating of plugs P813, P823, and P824 on the RE–247/FRN–22 (fig. 16). Check wiring to TB1901 on meter panel. Check contacts of relay O 402 in the RE–247/FRN–22 (fig. 263). (Transmitting equipment No. 1 only). Check contacts of relay O 404 in the RE–247/FRN–22. (Transmitting equipment No. 2 only). Check the seating of the plug in receptacle J902 on the O–371/FRN–20 (fig. 16). Check contacts on relay K901 on the O–371/FRN–20 (fig. 211).
			Goniometer motor operates.	Check fuse F1 on the goniometer (fig. 30). Check seating of plug P1803 on the goniometer (fig. 16).

Step	Component	Action	Normal indications	Corrective measures
18	Transmitter (fig. 13)	Set the meter switch to the HIGH VOLTAGE position.	Approximately 30 seconds after dialing 8 or 6 in step 17 above, the meter indicates a minimum of 500 volts.	Check the seating of plugs P1806 and P1807 (fig. 16). On PP–1331/FRN–20 make the following checks: Check fuses F1, F2, F4, and F5 (fig. 242) Check tubes V1, V2, and V4 (fig. 243 and par. 226). Check thermal relay S3 and relays S4 and S5 (fig. 242). Check adjustment of R9 (par. 82*b*). Check wiring to TB1. Check wiring to terminal E1.
19	Transmitter	Set the meter switch to the OSC PLATE position.	Meter indicates 8 to 10 milliamperes (ma).	Check tube V1 (fig. 243). Check crystal Y1. Check fuse F3 on PP–1331/FRN–20 (fig. 242). Check tube V3 on PP–1331/FRN–20.
20	Transmitter	Set the meter switch to the 1ST AMP GRID position.	Meter indicates 1 to 1.6 ma.	Check tube V2. Check adjustment of OSC PLATE tuning control (fig. 36).
21	Transmitter	Turn meter switch to 1ST AMP PLATE position.	Meter reads 24 to 32 ma	Check V2.
22	Transmitter	Turn meter switch (fig. 36) to 2ND AMP GRID position.	Meter indicates 1.4 to 3 ma.	Check adjustment of 1ST AMP PLATE tuning control (par. 39). Check adjustment of R5 on PP–1331/FRN–20 (par. 39).
23	Transmitter	Turn meter switch to 2ND AMP PLATE position.	Meter indicates 30 to 54 ma.	Check tube V3 (par. 121). Check adjustment of EXCITATION CONTROL (par. 39).
24	Transmitter	Turn meter switch to FINAL AMP GRID position.	Meter indicates 7 to 10 ma.	Check adjustment of 2ND AMP PLATE tuning control (par. 39). Check adjustment of EXCITATION CONTROL (par. 39).
25	Transmitter	Turn meter switch to FINAL AMP SCRN position.	Meter indicates 20 to 27 ma.	Check V4.
26	Transmitter	Turn meter switch to FINAL AMP TOTAL position.	Meter indicates 180 to 220 ma.	Check adjustment of FINAL AMP GRID tuning control (par. 39). Check adjustment of FINAL AMP PLATE tuning control (par. 39). Check adjustment of ANTENNA LOADING control (par. 39). Check V4.
27	Transmitter	Turn meter switch to MOD TOTAL position.	Meter indicates approximately 70 ma (55 ma unmodulated).	Check V5, V6, V7, and V8 (fig. 19).
28	Modulation eliminator	Turn meter switch S2 (fig. 237) to the LIMITER CATHODE position.	Meter indicates approximately the same as the indication recorded during initial adjustments (par. 46).	Check fuse F1. Check seating of plugs P1, P1804, and P1805 (fig. 16). Check tube V4 (fig. 18). Check tube V2. Check relay K1 (fig. 237).

Step	Component	Action	Normal indications	Corrective measures
29	Modulation eliminator	Turn meter switch to FINAL AMP PLATE position.	Meter reads approximately the same as the indication recorded during initial adjustment (par. 46).	Check tube V1. Check tube V2 for gas.
30	Modulation eliminator	Turn meter switch to DIODE LEVEL position.	Meter reads approximately the same as the indication recorded during initial adjustment (par. 46).	Check V3. Check V1.
31	Meter panel (fig. 232)	Observe indications on the FREQUENCY and VOLTS meters.	Approximately 60 seconds after dialing 8 or 6 in step 17 above, the VOLTS meter indicates 115 volts ac and the FREQUENCY meter indicates the output frequency of PP–1329/FRN–20 for the goniometer motor.	Refer to steps 32 and 33 below.
32	Meter panel	Set the CURRENT switch to the EQUIPMENT NO. 1 DRIVER TOTAL position or the EQUIPMENT NO. 2 DRIVER TOTAL position.	CURRENT meter indicates approximately 80 ma.	On PP–1329/FRN–20, make the following checks: Check fuses F1401 through F1404 and F1408 through F1410 (fig. 240). Check relays K1401 and K1402 (fig. 239). Check thermal relay S1401. Check V1403. Check seating of plug P1808 (fig. 16). On the AM–1246/FRN–20 (fig. 206), make the following checks: Check tubes V2 and V3. Check seating of plugs in receptacles J3 and J4.
33	Meter panel	Set the CURRENT switch to EQUIPMENT NO. 1 AMP TOTAL position or EQUIPMENT NO. 2 AMP TOTAL position.	CURRENT meter indicates approximately 120 ma.	On the PP–1329/FRN–20, make the following checks: Check fuse F1411 (fig. 239). Check tubes V1401 and V1402 (fig. 240). Check the wiring to terminals E1801 and E1802 in the CY–1899/FRN–22 (fig. 16). Check the wiring to terminals E1902 and E1906 in CY–2274/FRN–22A. (Transmitting equipment No. 1 only.) Check the wiring to terminals E1901 and E1905 in the CY–2274/FRN–22A. (Transmitting equipment No. 2 only.) On the AM–1246/FRN–20, make the following checks: Check connections to plates of V4 and V5 (fig. 206). Check V1, V4, and V5.

Step	Component	Action	Normal indications	Corrective measures
33	Meter panel—Con.			On the O–371/FRN–20, make the following checks: Check fuses F901 and F902 (fig. 213). Check thermal relay K902. Check V901 through V906. Check seating of plug in receptacle J901.
34	Monitor (fig. 32)	Observe the three red pilot lamps, designated ALARMS.	Three red alarm pilot lamps are out.	If the three red alarm pilot lamps are lighted, make the following checks: Check the seating of plugs P9 and P802 (fig. 16). Check V2, V10, and V19 (fig. 219). Check the seating of plug P401 on RE–247/FRN–22 (fig. 16). Check the seating of plugs P10 and P11 on the AN/FRA–14 (fig. 16). Check V1 in the AN/FRA–14 (fig. 204). If REFERENCE and COURSE pilot lamps are lighted, check V1, V6, and V17 (fig. 219). If VARIABLE and COARSE pilot lamps are lighted, check V3, V7, and V16. If COURSE pilot lamp only is lighted, make the following checks: Make sure that personnel, vehicles, or other objects which may affect the pattern radiated from the antenna are not in the immediate vicinity of the AN/FRA–14. Check V4, V5, V8, V11, V12, V15, and V18. Check all RF cables for loose or defective connectors. Check V2 in the modulation eliminator (fig. 238).
35	Monitor	Set the LEVEL switch to the INPUT position.	LEVEL METER indicates 100 percent.	Check V13 and V14 (fig. 219). Check V1 in field detector (fig. 204).
36	Monitor	Set the LEVEL switch to the REF position.	LEVEL METER indicates 100 percent.	Check V2.
37	Monitor	Set the LEVEL switch to the VAR position.	LEVEL METER indicates 100 percent.	Check V2 (fig. 219).
38	Monitor	Hold the TEST switch in the REF position and note the amount of pointer deflection on the COURSE RELAY meter.		

Step	Component	Action	Normal indications	Corrective measures
39	Monitor	Manually hold relay RY1 (fig. 220(4)) in the energized position and hold TEST switch in VAR position.	Pointer on COURSE RELAY meter deflects the same amount (but in opposite direction) as in step 38 above.	Check adjustment of R37 (par. 53).
40	C-1738/FRN-20	Dial 5.		
41	Monitor	Hold TEST switch in the REF position until the three red pilot lamps, designated ALARMS, light.	Transmitting equipment is turned off.	On the C-1840/FRN-22, make the following checks: Check fuse F601 (fig. 251). Check seating of plugs P801, P819, and P820 (fig. 16).
			After approximately 90 seconds, meters on transmitting equipment No. 1 show an indication and green EQUIPMENT NO. 1 pilot lamp lights.	See items 10 and 11 on chart in paragraph 236*c*.
			After approximately 2½ minutes, red pilot lamps, designated ALARMS, go out.	See items 10 and 11 on chart in paragraph 236*c*.
42	Monitor	Five minutes after performing step 41 above, hold TEST switch in the VAR position until the three red pilot lamps, designated ALARMS, light.	Transmitting equipment No. 1 is turned off.	See items 10 and 11 on chart in paragraph 236*c*.
			After approximately 90 seconds, meters on transmitting equipment No. 2 show an indication.	See items 10 and 11 on chart in paragraph 236*c*.
			After approximately 2½ minutes, red pilot lamps, designated ALARMS go out.	See items 10 and 11 on chart in paragraph 236*c*.
43	C-1738/FRN-20	Five minutes after performing step 42 above, dial 10.	Transmitting equipment No. 2 goes off.	
44	C-1738/FRN-20	Place LOCAL-REMOTE switch in REMOTE position.		
45	Antenna pedestal	Turn circuit breaker K1005 to OFF. (Leave all other circuit breakers in the ON position.)	Shelter lights go out.	

d. Chart for Remote Control Point.

Step	Component	Action	Normal indications	Corrective measures
1	Remote control cabinet (fig. 16).	Connect the power cable to a 115-volt ac outlet.	Alarm buzzer sounds if the ALARM SELECTOR on remote control unit is in any position except the down position.	On remote control unit, make the following checks: Check seating of plug P3 (fig. 16). Check fuse F501 (fig. 222). Check buzzer I502. Check the contacts on relays O501 and O502. Check the contacts on the ALARM SELECTOR switch.
2	Remote control unit	Set ALARM SELECTOR to down position.	Alarm buzzer is silenced	Check the contacts on the ALARM SELECTOR switch.
3	Remote control unit	Dial 9 for transmitting equipment No. 1 or 7 for transmitting equipment No. 2.	Alarm buzzer sounds	Check wiring to terminals 1, 2, and 10 of E501 (fig. 16). Check contacts on the ALARM SELECTOR switch. Check the contacts on relay O502 (fig. 222). Within the shelter, make the following checks: Check the wiring to terminals 1 and 2 of TB804 in the CY–1897/FRN–22 (fig. 16). Check wiring to E201 on the C–1738/FRN–20 (fig. 16). Check adjustment of R201 in the C–1738/FRN–20 (par. 36). Check adjustment of R9 on the PP–1331/FRN–20 (par. 38*b*).
			Amber TRANSMITTER ON pilot lamp lights.	Check pilot lamp.
4	Remote control unit	Place ALARM SELECTOR in center position.	Alarm buzzer is silenced and amber TRANSMITTER ON pilot lamp remains lighted.	
5	Remote control unit	Dial 8 for transmitting equipment No. 1 or 6 for transmitting equipment No. 2.	Alarm buzzer remains silent and amber TRANSMITTER ON pilot lamp remains lighted.	
6	Remote control unit	Wait 90 seconds after dialing 8 or 6 in step 5 above. Then set ALARM SELECTOR in the up position.	Green VOR ON pilot lamp lights and the alarm buzzer remains silent.	Check pilot lamp. Refer to the chart for omnirange site.
7	Microphone	Alternately press and release the press-to-talk bar.	Green VOR ON pilot lamp goes out when the press-to-talk bar is pressed.	Check seating of plug in MICROPHONE receptacle on remote control unit. Check switch in microphone. Check relay O501 (fig. 222).
8	Remote control unit	Dial 10 to turn the equipment off.	Alarm buzzer sounds and green VOR ON pilot lamp goes out.	
9	Remote control unit	Place the ALARM SELECTOR in the down position.	Alarm buzzer is silenced.	

e. Use of Proper Procedures. After both equipments have been checked for proper operation, and if either one can be used as a navigational facility, refer to paragraphs 238 through 247 and troubleshoot the faulty equipment; use the equipment test switches. If neither equipment can be put into operation, refer to paragraphs 231 through 237 and troubleshoot the equipment; use the starting procedure.

f. Remote Control Point Procedures. If both equipments operate by dialing at the omnirange site only, the fault exists in the remote control circuit.

(1) Refer to paragraph 36*g* and *h* and measure the loop resistance of the telephone line.

(2) Set the LOCAL-REMOTE switch in the REMOTE position and instruct the operator to hold the dial on the remote control unit in the cocked position. Measure the voltage across the coil of relay O 202; it should be 10 to 14 volts. If no voltage is present, check rectifier CR201 and resistors R201 and R202 in the C–1738/FRN–20 (fig. 246). If these parts are functional, troubleshoot the remote control unit (pars. 382–390).

230. Test Equipment Required for Troubleshooting AN/FRN–22A

a. Test Equipment. The following chart lists test equipment required for troubleshooting Radio Transmitting Set AN/FRN–22A, the associated technical manuals, and the assigned common names.

b. Test Equipment Chart.

Test equipment	Technical manual	Common name
Spectrum Analyzer TS–723/U	TM 11–5097	Spectrum analyzer.
Audio Oscillator TS–382A/U	TM 11–2684A	AF oscillator.
Directional Wattmeter, Thru-line Model 43 (Bird Electronics Corp., Cleveland, Ohio).		Line wattmeter.
Electronic Multimeter TS–505/U	TM 11–5511	vtvm.
Frequency Meter AN/URM–32	TM 11–5120	AN/URM–32.
Frequency Meter FR–67/U	TM 11–2698	FR–67/U.
Gram Gauge TL–559/U		Gram gage.
Multimeter ME–77/U	TM 11–6625–203–12	Multimeter.
Oscilloscope, DuMont Type 2559A		Oscilloscope.
Power Supply PP–1243/U		
RF Wattmeter AN/URM–43A	TM 11–5133	Load wattmeter.
RF Signal Generator Set AN/URM–25	TM 11–5551	AN/URM–25.
Signal Generator SG–13/ARN	TM 11–5556	SG–13/ARN.
Electron Tube Test Set TV–2/U	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U	TM 11–5083	TV–7/U.
Tool Equipment TE–113	SIG 6 TE–113	Tool kit.
Voltmeter, Meter ME–30A/U	TM 11–5132	AF vtvm.
Field Detector (Portable, CAA 2943)		Field strength meter.
Modulator MD–83A/ARN		vor modulator.

c. Equipment and Supplies. Additional equipments and supplies required for troubleshooting are listed in the applicable sections. Power supplies shown are either units removed from the omnirange set or from spare stock and tested in accordance with instructions contained in chapter 6. It is not feasible to patch in other types of power supplies to energize a component for troubleshooting.

Section II. TROUBLESHOOTING BASED ON STARTING PROCEDURE

231. General Troubleshooting Instructions

Instructions in this section are to be followed when both equipments are inoperative, as determined in paragraph 229 or by operating personnel. If either equipment can be used as a navigational facility, proceed to paragraph 238 through 247.

232. Scope of Troubleshooting by Starting Procedure

The starting procedure method of troubleshooting is used when the complete station is inoperative. This symptom usually is caused by a component common to both transmitting equipments, but could be caused by trouble in each equipment. This method of troubleshooting should be used only until one equipment has been repaired and can be placed on the air as a navigational station. The purpose of this section is to sectionalize the fault to the responsible circuit as quickly as possible.

233. Troubleshooting Reference Data

The following data will be helpful to the maintenance man using the troubleshooting charts in this section:

Reference	Data
Par. 233*a*	Fuses.
Par. 233*b*	Interlocks.
Fig. 16	Radio Transmitting Set AN/FRN-22A, cording diagram.

Reference	Date
Fig. 148	Radio Transmitting Set AN/FRN–22A, ac power distribution, schematic diagram.
Fig. 150	Interlock and protective circuits, schematic diagram.
Fig. 151	Dialing function No. 9, schematic diagram.
Fig. 152	Dialing function No. 8, schematic diagram.
Fig. 153	Dialing function No. 7, schematic diagram.
Fig. 154	Dialing function No. 6, schematic diagram.
Fig. 155	Radio Transmitting Set AN/FRN–22A, control circuits, schematic diagram.
Fig. 158	Modulating signal circuits, schematic diagram.
Fig. 298	Electrical Equipment Cabinet CY–1897/FRN–22, wiring diagram.
Fig. 299	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 1 wiring diagram.
Fig. 300	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 2 wiring diagram.
Fig. 301	Electrical Equipment Cabinet CY–2274/FRN–22A, wiring diagram.
Fig. 302	Electrical Equipment Shelter S–120/FRN–22, wiring diagram.
Fig. 303	Intercabinet wiring harness W19, wiring diagram.

a. Fuses. The following table lists all fuses in the omnirange set, their reference designations, ratings, the components in which the fuses are located, the circuits protected, and the applicable figure numbers:

Fuse reference designation	Component	Reference (fig. No.)	Ratings		Protected circuit
			Volts	Amp	
B/F1	Modulation Eliminator MX–1843/FRN–20.	31	250	1	Power transformer B/T1.
C/F1	Electrical Goniometer GO–12/FRN–20	30	250	0.8 (time lag).	Goniometer motor C/B1.
E/F1	Audio Frequency Oscillator O–373/FRN	25	250	2	Power transformer E/T2.
F1	Electrical Equipment Cabinet CY–1897/FRN–22 (inside blower housing).	29	250	3 (time lag).	Blower motor B1801.
F1	No. 1 Electrical Equipment Cabinet CY–1899/FRN–22 (inside blower housing).	29	250	3 (time lag).	Blower motor B1801.
F1	No. 2 Electrical Equipment Cabinet CY–1899/FRN–22 (inside blower housing).	29	250	3 (time lag).	Blower motor B1801.
F401	Relay Assembly RE–247/FRN–22	263	250	1	Filament transformer H/T1 in Antenna Group AN/FRA–14.
F501	Radio Set Control C–1739/FRN–20	222	250	1	Power transformer T502.
F601	Radio Set Transfer Control C–1840/FRN–22.	28	250	0.25	Motor of sequential timer S601.

Fuse reference designation	Component	Reference (fig. No.)	Ratings		Protected circuit
			Volts	Amp	
F901	Audio Frequency Oscillator O–371/FRN–20.	22	250	0.5 (time lag).	Power transformer T902.
F902	Audio Frequency Oscillator O–371/FRN–20.	22	250	0.5 (time lag).	Power transformer T902.
F1201	Power Supply PP–1415/FRN–22	245	125	2	Power transformer T1201.
F1202	Power Supply PP–1415/FRN–22	245	32	5	The 12-volt control and simplex voltage circuit.
F1401	Power Supply PP–1329/FRN–20	21	32	5	Ac input circuit of power supply.
F1402	Power Supply PP–1329/FRN–20	21	32	5	Ac input of power supply.
F1403	Power Supply PP–1329/FRN–20	21	250	0.3 (time lag).	Filament transformer T1401.
F1404	Power Supply PP–1329/FRN–20	21	250	0.3 (time lag).	Filament transformer T1401.
F1405	Power Supply PP–1329/FRN–20	21	250	1	Filament transformer T4 and T5 in Audio Frequency Amplifier AM–1246/FRN–20.
F1406	Power Supply PP–1329/FRN–20	21	250	1 (time lag).	Filament transformer T5.
F1407	Power Supply PP–1329/FRN–20	21	250	0. 3 (time lag).	Filament transformer T4.
F1408	Power Supply PP–1329/FRN–20	21	125	3. 2 (time lag).	Plate transformer T1402.
F1409	Power Supply PP–1329/FRN–20	21	125	3. 2 (time lag).	Plate transformer T1402.
F1410	Power Supply PP–1329/FRN–20	21	1, 000	0. 5	The 500-volt supply circuit for Audio Frequency Amplifier AM–1246/FRN–20.
F1411	Power Supply PP–1329/FRN–20	21	2, 500	0. 5	The 1,350-volt supply circuit for Audio Frequency Amplifier AM–1246/FRN–20.
F/F1	Course Monitor MX–1837/FRN–20	32	250	1. 5	Power transformer F/T4.
J/F1	Audio Frequency Amplifier AM–1247/FRN–20.	26	250	2	Power transformer J/T5.
K/F1	Voltage Regulator CN–358/FRN–22	269	250	3	Meter K/M1 and power transformer K/T5.
K/F2	Voltage Regulator CN–358/FRN–22	269	250	3	Motor K/B1, meter K/M1, and power transformer K/T5.
K/F3	Voltage Regulator CN–358/FRN–22	269	250	3	Motor K/B1 and motor winding of power transformer K/T3.
K/F4	Voltage Regulator CN–358/FRN–22	268	250	1	Power transformer K/T1.
K/F5	Voltage Regulator CN–358/FRN–22	268	250	1	Contacts of relays K/RL1 and K/RL2.
L/F501	Keyer KY–175/FRN	235	250	0. 15 (time lag).	Keyer motor L/M501.
M/F1001	Propeller Ventilating Fan HD–244/FRN–22 (on shelter roof stiffener).	8	250	5	Motor of Propeller Ventilating Fan HD–244/FRN–22.
P/F1	Electrical Equipment Cabinet CY–2274/FRN–22A (inside blower housing).	29	250	3 (time lag).	Blower motor B1901.
F1	Power Supply PP–1331/FRN–20	242	32	10	Primary power circuit.
F2	Power Supply PP–1331/FRN–20	242	32	10	Primary power circuit.
F3	Power Supply PP–1331/FRN–20	242	250	0. 5	Low-voltage supply.
F4	Power Supply PP–1331/FRN–20	242	250	0. 5	Bias supply.
F5	Power Supply PP–1331/FRN–20	242	250	0. 75	High-voltage supply.

b. Interlocks. The following table lists all interlocks used in the omnirange set and the reference symbol, location, and function of each interlock.

Interlock reference designation	Reference (fig. No.)	Location	Function
A/S3	257	Behind front panel of transmitter	Removes 115-volt ac from plate transformers T1 and T3 of PP–1331/FRN–20, and plate control relay K1402 in PP–1329/FRN–20, when transmitter front panel is removed.
B/S1	237	Behind front panel of modulation eliminator.	Removes 115-volt ac from power transformer T/T1, when modulation eliminator front panel is removed.
G/S1	207	Behind front panel of the AM–1246/FRN–20.	Removes 115-volt ac from plate relay K1402 in the PP–1329/FRN–20, when amplifier panel is removed.
P/S1903	227	Top right corner of door opening in the CY–2274/FRN–22A.	Removes 115-volt ac from plate control relay K1402 in the PP–1329/FRN–20, when rear cabinet door is opened (equipment No. 1).
P/S1904	227	Top right corner of door opening in the CY–2274/FRN–22A.	Removes 115-volt ac from plate control relay K1402 in the PP–1329/FRN–20, when rear cabinet door is opened (equipment No. 2).
P/S1905	227	Top right corner of door opening in the CY–2274/FRN–22A.	Removes 230-volt ac from blower motor B1901, and cabinet heaters HR1901, HR1902, HR1903, and HR1904, when the rear cabinet door is opened.
P/S1906	227	Top right corner of door opening in the CY–2274/FRN–22A.	Removes 230-volt ac from blower motor and cabinet heaters (with P/S1905), when rear cabinet door is opened.
S1	242	Behind front panel of the PP–1331/FRN–20.	Removes 115-volt ac from plate transformers T1 and T3 of the PP–1331/FRN–20 and plate control relay K1402 in the PP–1329/FRN–20, when the front panel is removed.
S801	225	Top right corner of rear door opening in the CY–1897/FRN–22.	Removes 230-volt ac from blower motor B801, and cabinet heaters HR801, HR802, HR803, and HR804, when cabinet door is opened.
S802	225	Top right corner of rear door opening in the CY–1897/FRN–22.	Removes 230-volt ac from blower motor and cabinet heaters (with S801), when cabinet door is opened.
S1402	239	Behind front panel of the PP–1329/FRN–20.	Removes 115-volt ac from plate relay K1402 in the PP–1329/FRN–20, when front panel is removed.
S1801	226	Top right corner of rear door opening in the CY–1899/FRN–22.	Removes 115-volt ac from plate transformers T1 and T3 in the PP–1331/FRN–20 and plate relay K1402 in the PP–1329/FRN–20, when cabinet door is opened.
S1802	226	Top right corner of rear door opening in the CY–1899/FRN–22.	Removes 230-volt ac from blower motor B1801 and cabinet heaters HR1801, HR1802, HR1803, and HR1804, when cabinet door is opened.
S1803	236	Top right corner of rear door opening in the CY–1899/FRN–22.	Removes 230-volt ac from blower motor and cabinet heaters (with S1802), when cabinet door is opened.

234. Equipment Required for Troubleshooting Radio Transmitting Set AN/FRN–22A

The following test and additional equipment are required for troubleshooting the omnirange set, using the troubleshooting charts based on starting procedures.

a. Test Equipment.

Test equipment	Technical manual	Common name
Electron Tube Test Set TV–2/U.	TM 11–2661	TV–2/U.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Audio Oscillator TS–382A/U.	TM 11–2684A	Af oscillator.
Voltmeter, Meter ME–30A/U.	TM 11–5132	Af vtvm.

b. Additional Equipment.

Qty	Description	Common name
12	Safety door switch (cap portion), Bryant Electric Company No. 4600A (Federal stock No. 5930-757-4130).	Interlock jumper plug.

235. Preliminary Checks for Troubleshooting Starting Procedures

Additional damage will be caused if power is applied to transmitting equipment in which a short circuit exists. Check for short circuits under any of the following conditions, before applying power to the transmitting equipment:

a. A replaced fuse that has blown repeatedly.

b. Smoke observed coming from a component.

c. Overheated parts observed or smelled.

d. Abnormal symptoms reported from operational tests that indicate possible short circuits.

236. Troubleshooting Chart Based on Starting Procedures

Warning: **Dangerous voltages exist in the four equipment cabinets in the shelter even when 10 has been dialed to turn the equipment off and the cabinet door interlocks are opened. This voltage is controlled by circuit breakers on the antenna pedestal.**

a. Use of Troubleshooting Chart. All procedures and corrective measures listed in this chart are performed at the omnirange site. The dialing steps indicated in the *Procedure* column are performed by using dial I 201 on the C-1738/FRN-20. Steps 1 and 2 in the troubleshooting chart are used to check the control circuits for equipment No. 1, the ac distribution from the antenna pedestal to the RE-247/FRN-22, and the antenna changeover relays. Step 3 is used to check the carrier control circuit. Steps 5 and 6 are used to check the control circuits and the ac distribution from the antenna pedestal to the RE-247/FRN-22 for equipment No. 2. Step 7 is used to check the carrier control circuit for equipment No. 2. Steps 8, 9, and 10 are used to check the monitoring, alarm, and automatic changeover circuits.

b. Preliminary Steps. Open the four cabinet doors and insert the interlock jumper plugs into interlock S1801 on each CY-1899/FRN-22 and S1903 and S1904 on the PP-1329/FRN-20 cabinet.

c. Troubleshooting Chart Based on Starting Procedure.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Dial 9	Minor switch K201 makes a clicking sound as it steps to position dialed.	K201 does not step	Measure the 12 volts dc at terminal board TB1202 on the PP-1415/FRN-22 (fig. 244). If the voltage is abnormal: Check fuses F1201 and F1202. Measure 115 volts ac across receptacle J1201 (fig. 227). If there is no voltage: Check circuit breaker N/K1004 (fig. 201). Check the wiring between N/K1004 and J1201 (figs. 298 and 299). Troubleshoot the PP-1415/FRN-22 (pars. 374-381). Troubleshoot the C-1738/FRN-20 (pars. 391-399).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Dial 9—Continued	Antenna relays N/K1008, N/K1009, and N/K1010 operate (fig. 201). All tube filaments of equipment No. 1 light. Motor L/M501 on keyer operates.	Relays N/K1008, N/K1009, and N/K1010 do not operate. Filaments do not light. Motor L/M501 does not operate.	Measure 115 volts ac between terminals 3 and 4, terminal board TB801 (fig. 225). If there is no voltage: Check relay O 401 in the RE-247/FRN-22 (fig. 263); if energized, check: Circuit breaker N/K1003 (fig. 201). Wiring between N/K 1003 and the RE-247/FRN-22 (figs. 16, 298, and 302). If relay O 401 is not energized: Check relay O 204 in the C-1738/FRN-20 (fig. 247). If O 204 is energized, check wiring between the C-1738/FRN-20 and the RE-247/FRN-22 (fig. 298). If relay O 204 is not energized, troubleshoot the 12-volt circuit (fig. 302).
			Relays N/K1008, N/K1009, and N/K1010 do not operate.	Check the wiring to relays (fig. 302). Check relays N/K1008, N/K1009, and N/K1010 (fig. 201).
2	Dial 8	Green EQUIPMENT NO. 1 pilot lamp I 202 on the C-1738/FRN-20 lights.	I 202 fails to light	Check pilot lamp I 202. Troubleshoot the 12-volt circuit (fig. 155). Check the wiring between the C-1738/FRN-20 and the RE-248/FRN-22 (fig. 298).
		Motor C/B1 on the goniometer operates.	C/B1 fails to operate	Remove thermal relay K902 from the O-371/FRN-20 (fig. 213) until the trouble is corrected. If relay O 402 in the RE-247/FRN-22 (fig. 263) is energized: Measure 115 volts ac at pins 1 and 2 of receptacle J402 (fig. 263); if abnormal, troubleshoot the RE-247/FRN-22 (pars. 419-425). If normal, check the wiring between the RE-247/FRN-22 and the O-371/FRN-20 (figs. 148, 298, 301, and 303). Check contacts of relay K901 in the O-371/FRN-20 (fig. 211). Check wiring between the O-371/FRN-20 and the goniometer (figs. 148, 299, 301, and 303). Check fuse C/F1 on the goniometer (fig. 228). Check motor C/B1 on the goniometer.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
2	Dial 8—Continued			If relay O 402 is not energized: Check the O 402 coil. Check the energized contacts of relay O 205 (fig. 247). Check the wiring between the RE–247/FRN–22 and the C–1738/FRN–20 (figs. 155 and 298). If O 205 is not energized: Check coil of O 205.
3	Turn meter switch A/S2 on the transmitter to HIGH VOLTAGE position.	Meter A/M1 on the transmitter indicates 500 volts.	No indication on meter A/M1.	Check fuse F5 on the PP–1331/FRN–20 (fig. 242). Check relay S5 in the PP–1331/FRN–20; if not energized: Check wiring between the PP–1331/FRN–20 and the C–1738/FRN–20 (figs. 155, 298, and 299). Troubleshoot the PP–1331/FRN–20 (pars. 364–373). If relay S5 is energized: Check wiring between the PP–1331/FRN–20 and the transmitter (fig. 299). Troubleshoot the PP–1331/FRN–20 (pars. 364–373). Troubleshoot the transmitter (pars. 408–418).
4	Observe alarm lamps on the monitor.	Alarm lamps are out	Alarm lamps lit	Proceed with No. 2 equipment troubleshooting to determine whether fault is in common equipment.
5	Dial 7	Minor switch K201 steps to position dialed.	K201 does not step	Check the wiring between the C–1738/FRN–20 and the RE–248/FRN–22 (figs. 155 and 298). Troubleshoot the C–1738/FRN–20 (pars. 391–399).
		All tube filaments of equipment No. 2 light. Motor L/M501 on keyer operates.	Filaments do not light and L/M501 does not operate.	Measure 115 volts ac between terminals 3 and 4, terminal board TB803 (fig. 225). If no voltage: Check relay O 403 in the RE–247/FRN–22 (fig. 263). If O 403 is not energized: Check relay O 301 in the RE–248/FRN–22 (fig. 265). If O 301 is energized, check wiring between RE–248/FRN–22 and RE–247/FRN–22 (fig. 298). If O 301 is not energized, troubleshoot the 12-volt circuit (fig. 155).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
6	Dial 6	Motor C/B1 on the GO–12/FRN–20 operates.	C/B1 fails to operate	Remove thermal relay K902 from the O–371/FRN–20 (fig. 213) until the trouble is corrected. Check relay O 404 in the RE–247/FRN–22 (fig. 263). If energized: Measure 115 volts ac at pins 5 and 6 of receptacle J402; if abnormal, troubleshoot the RE–247/FRN–22 (pars. 419–425). If the voltage is normal, check the wiring between the RE–247/FRN–22 and the O–371/FRN–20 (figs. 148, 298, 301, and 303). Check the contacts of relay K901 in the O–371/FRN–20 (fig. 211). Check the wiring between the O–371/FRN–20 and the goniometer (figs. 148, 300, 301, and 303). Check C/F1 and C/B1 on the goniometer. If relay O 404 is not energized: Check the O 404 coil. Check the wiring between the RE–247/FRN–22 and the C–1738/FRN–20 (figs. 155 and 298).
7	Turn meter switch A/S2 on the transmitter to the HIGH VOLTAGE position.	Meter A/M1 on the transmitter indicates 500 volts.	No indication on A/M1	Check fuse F5 on the PP–1331/FRN–20 (fig. 242). Check relay S5 in the PP–1331/FRN–20; if not energized: Check the wiring between the PP–1331/FRN–20 and the C–1738/FRN–20 (figs. 155, 298, and 300). Troubleshoot the PP–1331/FRN–20 (pars. 364–373). If relay S5 is energized: Check the wiring between the PP–1331/FRN–20 and the (fig. 300). Troubleshoot the PP–1331/FRN–20 (pars. 364–373). Troubleshoot the transmitter (pars. 408–418).
8	Observe the alarm lamps on the monitor.	Alarm lamps out	Alarm lamps lit	If the alarm lamps are lit in both steps 4 and 8, troubleshoot the antenna (pars. 248–255.) Troubleshoot the AN/FRA–14 (pars. 256–262). Check the cabling between the AN/FRA–14 and the monitor (fig. 16).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
8	Observe the alarm lamps on the monitor—Con.			Troubleshoot the monitor (pars. 306–315).
9	Dial 5	No indications.		
10	Manually alarm the omnirange set by holding TEST switch on monitor in REF position.	The C–1840/FRN–22 immediately starts operating.	The C–1840/FRN–22 does not operate.	Check the wiring between the monitor and the C–1840/FRN–22 (figs. 159 and 298). Troubleshoot the C–1840/FRN–22 (pars. 400–407).
		After 4 minutes, the other equipment is on the the air.	Other equipment does not turn on.	Check the wiring between the C–1840/FRN–22 and the C–1738/FRN–20 (figs. 155 and 298). Troubleshoot the C–1840/FRN–22 (pars. 400–407).
11	Same as item 10, but hold TEST switch in VAR position.			

237. Troubleshooting Voice-Modulation Signal Circuit

a. Troubleshooting the voice-modulation signal circuit includes the microphone, Radio Set Control C–1739/FRN–20, Audio Frequency Amplifier AM–1247/FRN–20, simplex telephone line, Radio Set Control C–1738/FRN–20, and Relay Assembly RE–248/FRN–22.

***Warning:* During these troubleshooting procedures, all circuits are energized with high voltage. Take adequate precautions to avoid electrical shock.**

b. To perform an operational check of the voice-modulating signal circuit, make the test equipment connections indicated in paragraph 45*a* and *b*. Do not make any of the adjustments listed because this would tend to obscure defective operation and cause failure after a short operating period. When the test equipment has reached a stable condition, and the operator has been alerted, perform the following operational steps:

(1) With LOCAL-REMOTE switch S202 in the REMOTE position, dial 9, then 8, and allow the equipment to warm up.

(2) Set the AF oscillator for 1.75-millivolt output at 1,000 cps in accordance with TM 11–2684A. Use figure 158 for signal tracing assistance.

(3) Observe the results of (1) and (2) above when the operator presses the microphone push-to-talk switch, and compare those results with the troubleshooting chart below.

c. A troubleshooting chart for the voice-modulating signal circuits follows:

Indication	Probable trouble	Procedure
No, or low, voice modulation	AM–1247/FRN–20 defective	Check the output at term. 5 and 6 of terminal board E501 with the AF vtvm in the remote control unit (fig. 260). The output should be 1.73 volts. If no voltage exists, or it is very low, troubleshoot the AM–1247/FRN–20 (pars. 274–284).
	Microphone defective	Check the microphone cord and switch continuity. Replace the microphone.
	Remote control unit defective	Check the output at term. 1 and 2 of terminal board E501. If no output exists, troubleshoot the remote control unit (pars. 382–390).
	C–1738/FRN–20 defective	Check the output at pins 2 and 3 of filter FL201 (fig. 247). If no output exists, troubleshoot the C–1738/FRN–20 (pars. 391–399).
	RE–248/FRN–22 defective	Check the output at term. 9 and 10 of terminal board TB1801 in the CY–1899/FRN–22 (fig. 16). If no output exists, troubleshoot the RE–248/FRN–22 (pars. 426–433).

Section III. INTERUNIT TROUBLESHOOTING

238. General

This section provides troubleshooting information necessary to localize a fault to a particular unit and is used only when one equipment is on the air as a navigational facility. Troubleshooting information given in this section applies to both equipment No. 1 and equipment No. 2. Reference designations listed in this section are for equipment No. 1. When troubleshooting equipment No. 2, refer to the chart in paragraph 243*a* for the proper reference designation. Controls and connectors not listed in the chart are the same for both equipments.

239. Interunit Troubleshooting Reference Data

Reference material useful in interunit troubleshooting is listed below.

Figure No.	Caption
2 (TM 11–5825–205–12).	Equipment grouped around antenna pedestal, front view.
3 (TM 11–5825–205–12).	Equipment grouped around antenna pedestal, rear view.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
262, 263	Relay Assembly RE–247/FRN–22, control locations.
36	Radio Transmitter T–573/FRN–20, control locations.
226	Electrical Equipment Cabinet CY–1899/FRN–22, interlock switch locations.
232	Indicator Panel SB–830/FRN–22A, control and indicator locations.
47	Oscilloscope modulation patterns.
148	Ac power distribution circuits, schematic diagram.
150	Interlock and protective circuits, schematic diagram.
155	Control circuits, schematic diagram.
156	Frequency-regulated supply circuits, schematic diagram.
157	Transmitting circuits, schematic diagram.
158	Modulating signal circuits, schematic diagram.
211, 212, 213	Audio Frequency Oscillator O–371/FRN–20, interior view.
214	Relay adjustment data.
225	Electrical Equipment Cabinet CY–1897/FRN-22, interior view.
226	Electrical Equipment Cabinet CY–1899/FRN–22, interior view.
227	Electrical Equipment Cabinet CY–2274/FRN–22A, interior view.
228, 229, 230	Electrical Goniometer GO–12/FRN–20.
262, 263	Relay Assembly RE–247/FRN–22.
264	Relay adjustment data.
264	Relay adjustment data.
266	Relay Assembly RE–248/FRN–22, rear view.
298	Electrical Equipment Cabinet CY–1897/FRN–22, wiring diagram.
299	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 1 wiring diagram.
300	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 2 wiring diagram.
301	Electrical Equipment Cabinet CY–2274/FRN–22A, wiring diagram.
303	Intercabinet wiring harness W19, wiring diagram.

240. Equipment Required for Interunit Troubleshooting

a. Test Equipment. The test equipment required for interunit troubleshooting is listed below with the applicable technical manual and the common name assigned to each.

Test equipment	Technical manual	Common name
RF Wattmeter AN/URM–43A.	TM 11–5133	Load wattmeter.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Oscilloscope, DuMont Type 2559A.		Oscilloscope.
Voltmeter, Meter ME–30A/U.	TM 11–5132	AF vtvm.

b. Additional Equipment. The additional equipment required for interunit troubleshooting and the common names assigned are listed below.

Qty	Description	Common name
12	Safety door switch (cap portion) Bryant Electric Company No. 4600A (Federal stock No. 5930–757–4130).	Interlock jumper plug.
2	Jumper leads	Audio jumpers.

c. Preparation of Jumper Leads. The two audio jumpers required may be fabricated by attaching phone tip plugs on each end of two 4-inch pieces of #20 AWG stranded wire. If phone tip plugs are not available, carefully strip off 1 inch of the insulation and tin the wire ends with solder to hold the strands in place.

241. General Precautions

Care should be exercised to assure that proper loads are connected before turning the transmitting equipment on, either by dialing or by use of the test switches.

***Caution:* During the following troubleshooting, one equipment will be on the air; therefore, extreme caution against coming into contact with high voltage should be observed.**

242. Preliminary Steps

Before starting the interunit troubleshooting, the following preliminary steps must be completed:

a. Determine first, by using the procedures specified in paragraph 229, which equipment can be placed on the air and which equipment is inoperative. After determining which equipment is inoperative, proceed with the following steps *before attempting to place either equipment into operation.*

b. Refer to figure 16 and disconnect RF connector P18 from the top of the CY–1899/FRN–22 of the inoperative equipment and connect the load wattmeter to receptacle J1802. Refer to TM 11–5133 and set the load wattmeter for 60 watts.

c. Open the rear door of the CY–1899/FRN–22 and disconnect plug P15 from receptacle J3 (fig. 16) on the modulation eliminator. Connect the second load wattmeter, set for 15 watts, to receptacle J3.

d. Open the rear door of the CY–1897/FRN–22 and remove plug P806 from receptacle J304 located on the rear of the RE–248/FRN–22 (fig. 16) and connect it to test receptacle J302. Refer to figure 265 and place MOD ELIM TEST switch in the ON position. Connect an audio jumper lead between test jacks J305 and J307 and a second jumper lead between test jacks J306 and J308 (fig. 265).

e. Connect the oscilloscope to CARRIER TEST OUT receptacle on the transmitter as described in paragraph 45*a*.

f. Open the rear door of the CY–2274/FRN–22A and insert interlock jumper plugs into interlock receptacles S1903 and S1904 (fig. 227). Insert another jumper plug into interlock receptacle S1801 on the CY–1899/FRN–22 (fig. 226).

g. Dial the operative equipment into operation.

243. Troubleshooting Chart, Using Equipment Test Switches

a. General. The troubleshooting chart (*b* below), using equipment test switches, is for equipment No. 1 but applies equally to equipment No. 2 with the exception of the reference designations of controls and connectors. The applicable reference designations of controls and connectors that differ for each equipment are shown in the following chart:

Control	Equipment No. 1	Equipment No. 2	Figure No.
Operate switch	S401	S403	262
Test switch	S402	S404	262
Plug	P806	P807	16
Receptacle	J304	J303	16
RF connector	P18	P24	16

b. Troubleshooting Chart, Using Equipment Test Switches.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Place EQUIPMENT NO. 1 OPERATE switch S401 in TEST position and EQUIPMENT NO. 1 TEST switch S402 in the ON position (fig. 262).	Filaments in equipment No. 1 light.	None of the normal indications.	Check the contacts of relays O 401 and O 402 in the RE-247/FRN-22 (fig. 263).
		Motor M501 on the keyer operates.	------------------------	Troubleshoot the RE-247/FRN-22 (pars. 419-425).
		Motor B1 on the goniometer operates.	------------------------	Check the ac distribution circuit (fig. 148).
			M501 only does not operate.	Check fuse F501 on keyer (fig. 238). Check M501 (fig. 234). Check wiring between keyer and the RE-247/FRN-22 (fig. 298).
			B1 only does not operate.	Check fuse F1 on goniometer. Check B1 (fig. 228). Check the contacts of relay K901 in the O-371/FRN-20 (figs. 211 and 214). Check the ac distribution circuit between motor B1 and the RE-247/FRN-22 (figs. 148, 150, and 154).
		After approximately 60 seconds, relays K901 and K902 in the O-371/FRN-20 make a loud click as they operate and motor B1 on the goniometer continues to operate.	K901 and K902 do not operate.	Check the closed contacts of thermal relay K902 (fig. 211). Check the coil of relay K901 (fig. 214).
			Motor B1 stops or operates irregularly.	Troubleshoot the PP-1329/FRN-20 (par. 244).
2	Press the TEST key S4 on the transmitter (fig. 36).	Wattmeter indicates 50 watts.	No, or low, indication on wattmeter.	Troubleshoot the transmitting circuits (par. 245).
3	Observe the oscilloscope pattern (fig. 60).	Oscilloscope pattern shows a subcarrier modulation depth of 30 percent and an identification tone modulation depth of 10 percent.	No, or low, modulation---	Troubleshoot the modulating signal circuits (par. 246).

244. Troubleshooting Frequency Regulating Circuits

a. General. When the procedures in the chart (par. 243*b*) indicate trouble in the frequency regulating circuits, proceed with the steps given in the following chart to localize the fault.

b. Troubleshooting Chart for the Frequency Regulated Circuits.

Indication	Probable trouble	Procedure
Motor B1 on the goniometer stops shortly after starting equipment.	No output from PP–1329/FRN–20.	On the meter panel turn LINE switch S1902 to EQUIPMENT NO. 1 position and CURRENT switch S1901 to EQUIPMENT NO. 1 DRIVER TOTAL position (fig. 232). Read 115 volts on VOLTS meter M1903. Read 80 ma on CURRENT meter M1901. If there is no indication on either meter: Check the wiring between the meter panel and the O–371/FRN–20 (fig. 301). Check the wiring between the meter panel and the AM–1246/FRN–20 (fig. 301). Measure 1,350 volts dc between terminal E1902 or E1906 and ground (fig. 227). Measure 500 volts dc between receptacle J3 and ground (fig. 206). Dc voltages are abnormal: Check the wiring between the AM–1246/FRN–20 and the PP–1329/FRN–20 (figs. 299, 301, and 303). Troubleshoot the PP–1329/FRN–20 (pars. 355–363). Dc voltages normal: Troubleshoot the AM–1246/FRN–20 (pars. 263–273). Troubleshoot the O–371/FRN–20 (pars. 285–294).

245. Troubleshooting Transmitting Circuits

a. General. When the procedures in the chart (par. 243*b*) indicate trouble in the transmitting circuits, proceed with the steps indicated in the following chart to localize the fault.

b. Troubleshooting Chart for Transmitting Circuits.

Item	Indication	Probable trouble	Procedure
1	Load wattmeter connected to J1802 does not indicate 50 watts (par. 242*b*).	Transmitter defective	Measure 500 volts dc at terminal E1 on the PP–1331/FRN–20 (fig. 243). If normal, troubleshoot the transmitter (pars. 408–418). If abnormal, troubleshoot the PP–1331/FRN–20 (pars. 364–373).
2	Load wattmeter connected to J3 does not indicate 6 watts (par. 242*c*).	Modulation eliminator defective.	Troubleshoot the modulation eliminator (pars. 346–354).

246. Troubleshooting Modulating Signal Circuits

a. General. When the procedures given in the chart (par. 243*b*) indicate trouble in the modulating signal circuits, proceed with the steps given in the following chart to localize the fault.

b. Troubleshooting Chart for Modulating Signal Circuits.

Item	Indication	Probable trouble	Procedure
1	Oscilloscope connected to J3 of transmitter indicates no modulation (par. 242*e*).	Modulator section of transmitter defective.	Troubleshoot transmitter (pars. 408–418).
2	Oscilloscope indicates no subcarrier modulation (par. 45*c* and fig. 47).	Subcarrier section of goniometer defective.	Check wiring between transmitter and goniometer (figs. 158 and 300 or 301). Troubleshoot goniometer (pars. 324–333).
3	Oscilloscope indicates no keyed tone modulation (par. 45*d* and fig. 47).	O–373/FRN defective	Measure 6 volts signal voltage at output of O–373/FRN (fig. 158). If abnormal: Troubleshoot O–373/FRN (pars. 295–305). If normal: Check wiring between O–373/FRN and keyer (fig. 299). Troubleshoot keyer (pars. 339–345). Check wiring between keyer and RE–248/FRN–22 (fig. 299). Troubleshoot RE–248/FRN–22 (pars. 426–433). Check wiring between RE–248/FRN–22 and C–1738/FRN–20 (fig. 299). Troubleshoot C–1738/FRN–20 (pars. 391–399). Check wiring between RE–248/FRN–22 and goniometer (figs. 299, 304, and 300 or 301). Check attenuator R17 in the goniometer (fig. 229). Check wiring between the goniometer and transmitter (fig. 300 or 301).

247. Troubleshooting Intercommunication Circuits

a. General. The intercommunication circuits include the two handsets, Radio Set Control C–1739/FRN–20, Radio Set Control C–1738/FRN–20, and the simplex telephone line (fig. 160). Defective handsets (HS1 and HS2) are best located by substitution of a handset of known quality. If the trouble is corrected, repair the handset by checking the cord continuity and replacing the receiver or transmitter as required.

b. Troubleshooting Chart for Intercommunication Circuits.

Item	Indication	Probable trouble	Procedure
1	No communication between the remote site and the local site. No monitor audio at the remote site. Dialing functions normal.	Defective handsets	Repair or replace the handset.
		Dial I 501 contacts defective	Troubleshoot the remote control unit (pars. 382–390).
		RING-TALK switch S201 defective.	Troubleshoot the C–1738/FRN–20 (pars. 391–399).
2	No intercommunication, monitor audio normal.	Defective handset HS2	Repair or replace the handset.
		RING-TALK switch S201 defective.	Troubleshoot the C–1738/FRN–20 (pars. 391–399).
3	Intercommunication normal, no monitor audio at the remote site, normal at the MONITOR jack J201.	C–1738/FRN–20 defective	Troubleshoot the monitor audio circuit (fig. 159) in the C–1738/FRN–20 (pars. 391–399).

248. General

a. Troubleshooting for the antenna is divided into two parts: Troubles reported from flight checks of the omnirange set, and alarms indicated by the monitor. Full consideration is given in this section to the possibility of compensation in the monitor calibration for faults which go undetected except by flight check. The troubleshooting procedures are based upon three fundamental categories: Coaxial cables, components, and signal input to the antenna. When servicing the antenna circuit, the omnirange set must be removed from navigational service. Notify the proper authority of the out-of-service condition before beginning the troubleshooting procedures.

b. The antenna is a rugged-built component, and although troubles encountered may appear to be caused by the antenna, they are usually caused by external faults. Virtually all internal antenna troubles are caused by moisture and corrosion, which can be located by intensive visual inspection. Do not consider the antenna defective until all procedures given in this section have been thoroughly checked; most apparent antenna faults are actually in the circuits which excite the antenna.

***Caution:* Do not bend, dent or place strains on the internal parts of the antenna during troubleshooting or visual inspection because this will upset the factory calibrations. Exercise extreme care when handling the radomes to avoid cracking or distorting the area around the slot by overtightening the attaching parts. Do not alter the position of the antenna parts and change no adjustments unless specifically instructed to do so.**

249. Troubleshooting Reference Data

The following list of illustrations will be useful when troubleshooting the antenna:

Figure No.	Caption
39	Antenna AT–669/FRN–22, radome locations.
40	Antenna AT–669/FRN–22, typical tuning chart.
41	Antenna AT–669/FRN–22, upper slot tuning adjustment locations.
42	Antenna AT–669/FRN–22, lower slot tuning adjustment locations.
43	Antenna AT–669/FRN–22, feeder tuning adjustment locations.
85	Feed points and feed line tuning diagram.
86	Antenna AT–669/FRN–22, figure-of-eight radiation pattern.
87	Rotation of the figure-of-eight pattern.
88	Antenna AT–669/FRN–22, total radiation pattern.
89	Antenna AT–669/FRN–22 heaters, schematic diagram.
169	Antenna AT–669/FRN–22, test setup.
203	Antenna AT–669/FRN–22, heater and cable replacement.

250. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting the antenna is listed below with the applicable technical manual and the common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Field Detector (Portable, CAA Model 2943).		Field strength meter.
RF Wattmeter AN/URM–43A (2 required).	TM 11–5133	Load wattmeter.
Directional Modulator MD–83A/ARN.		VOR modulator.
Wattmeter, Thru-line Model 43 (2 required) (Bird Electronics Corp., Cleveland, Ohio).		Line wattmeter.

b. Additional Equipment Required. The additional equipment required to troubleshoot the antenna is listed below with the common name assigned to each.

Quantity	Description	Common name
4	Coaxial cables fabricated from RG–8/U cable and having UG–21B/U coaxial connectors (Federal stock No. 5935–149–4236) on each end. One cable to be 10 feet in length, the remaining three to be 4 feet in length. (See chapter 5 for fabrication procedure.)	Test coaxial cables.
8	Safety door switch (cap portion) Bryant Electric Company No. 4600A (Federal stock No. 5930–757–4130).	Interlock jumper plug.

251. Removal and Reinstallation

a. General. The antenna normally will be serviced in position on top of the shelter and will require two men for best efficiency. Installation instructions for the antenna are contained in paragraphs 11, 21, and 23. Removal will be obvious from these procedures.

b. Radome Removal and Reinstallation. Prior to removal of radomes, note any identification marks or provide marks which may be used to reinstall each radome on the original slot. The radome end marked TOP must be reinstalled on top. Do not make radiation tests with any of the radomes removed. The absence of a radome raises the resonant frequency of the slot. Before reinstallation of a radome, inspect the gaskets and mating surfaces and be sure that they form a weathertight seal. Replace any gaskets that are not a perfect fit and tighten screws sufficiently to obtain a tight seal but not enough to distort the metal around the radome or slot.

252. General Precautions

a. When radiation troubles are indicated, complete the procedures given in this section in the order given. This is necessary because some defects may appear to be in the antenna but are actually reflections from another portion of the antenna system.

b. Moisture in the antenna is the primary source of internal trouble and can be located by a thorough visual inspection. Do not perform troubleshooting procedures during electrical storms or remove the radomes during rain, snow, or heavy fog conditions. Be extremely careful in handling radomes at all times.

c. Controls and adjustments inside the antenna should always conform to the tuning chart included with the antenna. (Do not use the chart shown in fig. 40.) Compensation for faulty operation by changing tuning control settings is permissible only under conditions indicated in this section, and then only for capacitors C1 and C2.

d. When making dc resistance measurements on the antenna system, consult the reference figures and schematics to be certain of the continuity being measured. Continuity may be indicated through an apparently open connection, because of a parallel circuit.

e. Improperly fabricated coaxial test or replacement cables can cause very serious difficulties during troubleshooting. Use exact procedures given in chapter 5 for all such fabrication. Observe critical dimensions and tolerances with regard to cable lengths.

253. Test Setup for Antenna Circuit

a. Equipment Calibration. The test setup for the antenna circuit requires that both transmitters be in perfect operating order and that the test equipment be calibrated to insure accuracy of the reflected power percentage (rpp) measurements. Complete the following steps on the transmitters and test equipment in the order given:

(1) With both equipments shut down, disable both O–373/FRN oscillators by disconnecting the ac power plug from receptacle E/J1 (fig. 16). Disable both goniometers by disconnecting the ac power plugs from receptacles C/J6, and plugs P1801 at receptacle C/J1. Install interlock jumper plugs in all rear door interlocks of CY–1897/FRN–22 and CY–1899/FRN–22.

***Warning:* Extremely high voltages are present in the cabinets at all times. Take adequate precautions against electrical shock that can be caused by contact with exposed terminals.**

(2) Connect one receptacle of the line wattmeter to transmitter No. 1, rf output plug A/P1 (fig. 16), and the load wattmeter to the remaining receptacle with a test coaxial cable (A, fig. 169). Install a 50-watt element in the line wattmeter, arrow toward load wattmeter. Dial No. 9 then No. 8.

(3) Both wattmeters should read 50 watts; if the transmitter rf output is other than 50 watts, adjust in accordance with paragraph 39. Should the power output of the transmitter be excessively low, troubleshoot in accordance with paragraphs 408 through 418.

(4) Check the reflected power percentage (rpp) of all wattmeters and test the coaxial cables (*b* below). The rpp for any combination must be less than 1 percent. Check and adjust the output of transmitter No. 2 in the same manner indicated in (2) and (3) above.

b. Reflected Power Percentage. When reflected

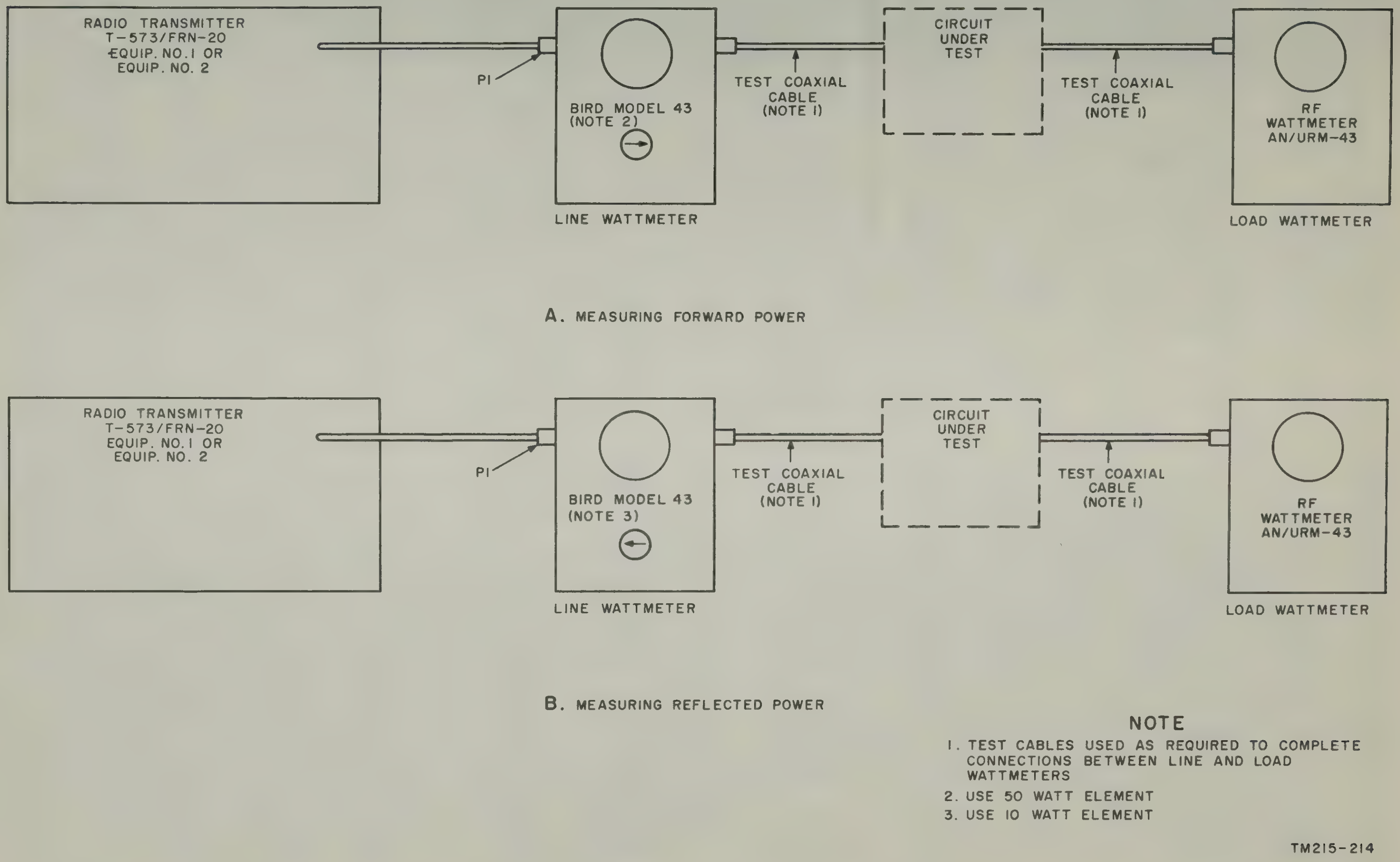


Figure 169. Antenna AT-669/FRN-22, test setup.

power percentage tests are specified in the charts or tests of this section, the following procedure is to be used.

(1) Be sure that equipment No. 1, test coaxial cables and wattmeters are calibrated as instructed in *a* above.

(2) Disconnect the coaxial cable from receptacle B/J2 on the modulation eliminator (fig. 16) and connect the cable to one of the line wattmeter receptacles.

(3) Disable equipment No. 1 O–373/FRN by disconnecting the ac power plug from receptacle E/J1. Disable the goniometer by removing the ac power plug from receptacle C/J6 and the connector plug from receptacle C/J1 on the goniometer subchassis.

(4) Connect one end of the circuit to be checked to the other receptacle of the line wattmeter. Connect the load wattmeter to the opposite end of the circuit to be checked. The line wattmeter always tests the component parts between the line wattmeter and the load (fig. 169).

Caution: **Do not energize equipment unless all rf outputs are terminated properly by their normal load or a load wattmeter. Use the 60-watt scale on the load wattmeter unless otherwise specified.**

(5) Measure forward power first by installing the 50-watt element in the line wattmeter with the arrow toward the load wattmeter line. Note the reading, deenergize the equipment, remove the 50-watt element, and install the 10-watt element with the arrow toward the transmitter.

Caution: **With the 10-watt element in the line wattmeter, be on the alert for an off-scale meter reading to avoid damage to the meter. Use the 50-watt element with the arrow toward the transmitter if necessary to troubleshoot under high reflected power conditions. *Do not change elements with equipment energized.***

(6) Compute reflected power percentage with the following formula:

$$\frac{\text{reflected power}}{\text{forward power}} \times 100 = \text{reflected power percentage.}$$

254. Antenna Circuit Troubleshooting.

a. General. Two charts contained in this paragraph indicates troubles that are localized by information gained from monitor alarms and flight checks. The information in the charts may be used separately or in combined form, whichever suits the conditions. Use figure 16 to assist in locating components to be checked.

b. Monitor Alarm Chart. The *Indication* column of the chart contains information on troubles obtained from the alarm lamps and indicators on the monitor panel. *Probable trouble* and *Procedure* columns indicate the method required to accurately locate the defective component.

Item	Indication	Probable trouble	Procedure
1	All three alarms lighted in both equipments.	Carrier levels very low	Check coaxial cables W3 and W5 (par. 255*b*). Check antenna relay N/K1010 (par. 255*c*). Check moisture and corrosion points (par. 255*f*).
		Defective AN/FRA–14	Troubleshoot the AN/FRA–14 (pars. 256–262).
		Defective monitor	Troubleshoot monitor (pars. 306–315). Replace antenna when all other possible troubles have been exhausted.
2	Same as item 1 above but one equipment only.	Defective transmitter	Troubleshoot transmitter (pars. 408–418).
		Reference carrier level low	Equipment No. 1, check coaxial cable W14 (par. 255*b*). Equipment No. 2, check coaxial cable W17 (par. 255*b*).
		Defective goniometer	No power to goniometer (pars. 238–247). Troubleshoot goniometer (pars. 324–333). No ac power to antenna relays, equipment No. 1 (pars. 231–237).
3	VARIABLE and COURSE alarms lighted, both equipments.	Variable carrier level low	Check coaxial cables W2 and W4 (par. 255*b*). Check antenna relays N/K1008 and N/K1009 (par. 255*c*). Check moisture and corrosion at antenna slot (par. 255*f*).
		Defective monitor	Troubleshoot the monitor (pars. 306–315). Replace the antenna when all other possible troubles have been exhausted.
4	Same as item 3 above but one equipment only.	Variable carrier level low	Check antenna relays N/K1008 and N/K1009 (par. 255*c*). Check the goniometer (par. 255*c* and *e*). Equipment No. 1, check coaxial cables W1, W13 and W15 (par. 255*b*). Equipment No. 2, check coaxial cables W1, W16, and W18 (par. 255*b*).
		Defective goniometer	Check the level and rpp (par. 255*d* and *e*). Troubleshoot the goniometer (pars. 324–333).
		Defective modulation eliminator.	Troubleshoot the modulation eliminator (pars 346–354). Adjust variable carrier modulation (par. 46) after other tests indicate normal operation.
5	REFERENCE and COURSE alarms lighted.	Subcarrier frequency shift	Troubleshoot goniometer subcarrier chassis (pars. 324–333.) Troubleshoot goniometer capacitor C18 (pars. 324–333). Check modulation adjustments (par. 49).
		Defective monitor	Troubleshoot monitor (pars. 306–315).
6	COURSE alarm lighted	Small course shift	Check antenna moisture and corrosion (par. 255*f*). Goniometer drive belt loose (par. 41). Unbalanced rpp in variable carrier feed to antenna. Check all variable coaxial cables (par. 255*b*) then refer to alinement instructions in chapter 5. Recheck items 1 and 2 above; they may cause small course shift without setting up level alarms.
		Defective monitor	Troubleshoot monitor (pars. 306–315).

c. Flight Check Chart. The *Indication* column of the chart contains information as received from a flight check crew after a flight check as outlined in paragraph 58. *Probable trouble* and *Procedure* columns outline the necessary steps to locate the defective component.

Item	Indication	Probable trouble	Procedure
1	Course errors at the four cardinal headings (positive errors on one pair of diagonally opposite headings and negative on the other pair), both equipments, COURSE alarm lighted.	Power level to one variable carrier slot pair low.	Check antenna relay N/K1008 or N/K1009 (par. 255*e*). Check coaxial cables W2 and W4 (par. 255*b*). Check for corrosion and moisture (par. 254*f*). If none of the above troubles appears, visual inspection is satisfactory, and there is an error of less than 1.5° perform variable-feed balance alinement in chapter 5. If the error is greater than 1.5°, the antenna is defective. After the above checks, replace antenna.
2	Same as above but one equipment only.	Same as item 1 above	Goniometer balun C/T1 or C/T3 defective. Check rpp (par. 255*d*). Check goniometer capacitor C17 output (par. 255*e*). Check antenna relay N/K1008 or N/K1009 (par. 255*c*). Equipment No. 1, check cable W13 or W15 (par. 255*b*). Equipment No. 2, check cable W16 or W18 (par. 255*b*). Check all corrosion points (par. 255*b*).
3	Same as item 1 above but no COURSE alarm given.	Same as item 1 above but monitor PHASE ZERO control has been reset for balance.	Complete all checks in item 1 above, and recalibrate monitor (par. 48).
		Defective monitor	Troubleshoot the monitor (pars. 306–315).
4	Large course errors at one pair of opposite cardinal headings only. Monitor does not give a COURSE alarm.	Same as item 1 above but subcarrier phase has been shifted to compensate for error at field detector site.	Complete all checks in items 1 and 2 above, and reset adjustment C/H1 on goniometers (par. 59).
5	Error shift in all courses from original installation curve, monitor gives COURSE alarm.	Subcarrier phase shifted	Troubleshoot the subcarrier circuits of goniometer (pars. 324–333). Perform the course alinement adjustment (par. 59).
6	Course width incorrect, both equipments.	Reference carrier output incorrect	Check antenna relay N/K1010 (par. 255*c*). Check coaxial cables W3 and W5 (par. 254*b*). Check for corrosion and moisture (par. 254*f*).
		Variable carrier output incorrect	Check coaxial cables W2 and W4 (par. 254*b*). Check antenna relays N/K1008 and N/K1009 (par. 254*c*).
7	Same as item 6 above but one equipment only.	Same as item 6 above	Troubleshoot the transmitter (pars. 408–418). Check all antenna relays (par. 255*c*). Equipment No. 1, check coaxial cables W13, W14, and W15 (par. 255*b*). Equipment No. 2, check coaxial cables W16, W17, and W18 (par. 255*b*).

Item	Indication	Probable trouble	Procedure
7	Course width incorrect—Continued		Check the goniometer (par. 255 *d* and *e*). Troubleshoot the modulation eliminator (pars. 346–354). Adjust the variable carrier modulation level (par. 46).
		Subcarrier modulation level incorrect	Troubleshoot goniometer subchassis (pars. 324–333). Adjust subcarrier modulation level (par. 45).
8	Excessive course error in one quadrant only.	Moisture and corrosion	Check reference feed line termination at antenna cylinder (par. 255*f*).
		New construction	May be necessary to relocate omnirange set.
9	Erratic courses, with weather changes.	High grass at omnirange site	Maintain grass at low level.
		Vehicles parked or moving about site	Remove vehicles from site.
		Trees on site with foliage change	Remove all trees from site.
		Antenna leakage	Check and reseal antenna (ch. 5).

255. Isolating Troubles

a. General. Use these procedures to isolate a trouble indicated in the troubleshooting charts (par. 254). It is not necessary to remove any of the units from their cabinets. The method used to check the components is based on the reflected power percentage. Check the transmitter, test coaxial cables, and test equipment to be used in accordance with instructions (par. 253) before starting the test in this paragraph.

***Caution:* Be sure that all connectors are tight and in good condition. Do not disconnect any connectors or change elements in the line wattmeter when either transmitting equipment is energized.**

b. Coaxial Cable Check.

(1) Connect the RF output plug A/P1 (fig. 16) of the transmitter to be used to one receptacle of the line wattmeter.

(2) Remove the coaxial cable to be checked and connect one end to the remaining line wattmeter receptacle. Connect the other end of the suspected component to the load wattmeter (fig. 169). Set the wattmeter on the 60-watt scale.

(3) Energize the transmitter to be used and check the rpp (par. 253*b*). If the rpp is greater than 1 percent, the component is defective and must be repaired or replaced in accordance with instructions contained in chapter 5.

c. Antenna Relay Check.

(1) Disconnect all coaxial cable connectors at the antenna relay assembly (fig. 16), and connect the line wattmeter to transmitter No. 1 RF output plug A/P1. Connect the second line wattmeter to RF output plug A/P1 of transmitter No. 2.

(2) Connect antenna relay receptacle N/J1005 to the transmitter No. 1 line wattmeter with a 4-foot test coaxial cable, and antenna receptacle N/J1003 to RF output plug A/P1 of transmitter No. 2 with a test coaxial cable.

(3) Connect the load wattmeter to antenna relay receptacle N/J1004 with a 4-foot test coaxial cable. Dial No. 9 then No. 8, and check equipment No. 1 rpp (par. 253*b*); dial No. 10 then No. 7 and No. 6, and check equipment No. 2 rpp. If either rpp is above 1 percent, repair or replace antenna relay N/K1008 as instructed in chapter 5.

(4) Repeat the above steps to check antenna 'relays N/K1009 (receptacles N/J1011, N/J1009, and N/J1010), and N/K1010 (receptacles N/J1008, N/—1006, and N/J1007).

d. Goniometer RPP Check.

(1) Connect the line wattmeter (50-watt element arrow toward goniometer) to the RF output plug A/P1 of the transmitter of the equipment which contains

the defective goniometer. Remove plug P14 from receptacle C/J4 on the goniometer and connect the line wattmeter to receptacle C/J4 with a 4-foot test coaxial cable.

(2) Connect a load wattmeter to each of the goniometer receptacles C/J3 and C/J5 with 4-foot test coaxial cables. (Plugs P1801 and P1803 to the goniometer must remain disconnected.) Energize the appropriate transmitter.

(3) Rotate the goniometer capacitor manually to 45°, 135°, 225°, and 315° on the azimuth plate (fig. 30) and check the rpp (par. 253*b*). If the rpp is greater than 1 percent at all four positions, balun T2 is defective; at 45° and 225°, balun T1 is defective; at 135° and 315°, balun T3 is defective. Replace defective baluns in accordance with instructions in chapter 5.

e. Goniometer Capacitor C17 Check.

(1) Connect the line wattmeter (50-watt element arrow toward the goniometer) to the RF output plug A/P1 of the transmitter of the equipment which contains the defective goniometer. Remove plug P14 from receptacle C/J4 on the goniometer and connect the line wattmeter to receptacle C/J4 with a 4-foot test coaxial cable.

(2) Connect a load wattmeter to each of the goniometer receptacles C/J3 and C/J5 with 4-foot test coaxial cables. (Plugs P1801 and P1803 to the goniometer must remain disconnected.) Energize the appropriate transmitter.

(3) Rotate the azimuth plate (fig. 30) to approximately 45° and accurately locate the minimum output on the load wattmeter connected to receptacle C/J5. Note the azimuth plate reading and locate the minimum at 225°. The two azimuth plate readings should not vary more than 1° from 45° or 225°.

(4) Repeat step (3) while observing the indication on the load wattmeter connected to receptacle C/J3 and check the azimuth plate settings of 135° and 315°.

(5) If the azimuth plate readings are out of tolerance in (3) or (4), replace the goniometer capacitor (ch. 5).

(6) Check balance of outputs at 0°, 90°, 180°, and 270°. The two wattmeters must indicate the same rf output from receptacles C/J3 and C/J5 within 2 percent at all four points.

(7) Check the maximum and minimum RF outputs at 45°, 135°, 225°, and 315°. The maximums must not be less than 93 percent of the power input to receptacle C/J4 and equal within 2 percent. The minimums must be less than 3.5 percent of the average of the four maximum RF outputs and equal within 2 percent. Rf outputs at 0°, 90°, 180°, and 270° must be between 69.7 and 71.7 percent of the average of the four maximum outputs. Replace the complete goniometer capacitor in accordance with instructions in chapter 5 if out of tolerance.

f. Moisture and Corrosion Points. The points listed below are the most common places where moisture and corrosion occur in the antenna circuit. A thorough visual inspection will locate the trouble; chapter 5 contains the corrective measures.

Trouble point	Check for
All coaxial cable connectors	Spread center pin socket. Corrosion and moisture at center pin insulator. Corrosion around shield braid and shield mating surface.
Reference carrier feed	Corrosion under terminal lugs and screw, where 200 ohm lines terminate on antenna cylinder.
Variable feed line tuning capacitors C1 and C2.	Moisture and corrosion inside enclosure.
Antenna slots	Moisture across slot insulators. Corrosion at feed contact points to cylinder.

Section V. ANTENNA GROUP AN/FRA–14 TROUBLESHOOTING

256. General

Troubleshooting the AN/FRA–14 is accomplished with the omnirange set performing its normal functions. The omnirange set must be shut down while preparations are made (par. 261*c*). Previous tests must indicate that the equipment in use is operating correctly, because the monitor will be deactivated during the procedures in this section. The AN/FRA–14 may be serviced at its operating location or on the test bench as desired by the technician.

257. Troubleshooting Reference Data

The following list of illustrations will be useful during troubleshooting of the AN/FRA–14.

Figure No.	Caption
1	Siting Radio Transmitting Set AN/FRN–22A.
9	Antenna Group AN/FRA–14, installation of dipole.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
27	Antenna Group AN/FRA–14, tube and control locations.
111	Antenna Group AN/FRA–14, schematic diagram.
159	Monitoring and alarm circuits, schematic diagram.
170	Antenna Group AN/FRA–14, voltage and resistance diagram.
204	Antenna Group AN/FRA–14, bottom interior view.
205	Antenna Group AN/FRA–14, top interior view.
292	Antenna Group AN/FRA–14, wiring diagram.

258. Equipment Required for Troubleshooting.

a. Test Equipment. The test equipment required is listed below, with the applicable technical manual and the common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment. The additional equipment required to troubleshoot the AN/FRA–14 is listed below with its common name.

Quantity	Description	Common name
1	Power input cable (fabrication par. 261*b*).	Power cable.
2	Safety door switch (cap portion) Bryant Electric Company No. 4600A (Federal stock No. 5930–757–4130).	Interlock jumper plug.

259. Removal and Reinstallation

The removal of the AN/FRA–14 is obvious when reference is made to the installation procedure given in paragraph 12 and figure 9. Access to the vacuum tube is made by removing the four screws which hold the cover containing receptacles J1 and J2. The opposite cover provides access to the remaining component parts. Be sure that all gaskets are in perfect condition and that covers fit snugly during reassembly to prevent moisture from entering the unit.

260. General Precautions

Do not change the setting of tuning capacitor C1 during troubleshooting; be careful when working around inductor L1 to avoid moving it. Make a tube socket resistance check (fig. 170, contained in separate envelope) before applying power for troubleshooting. When removing the antenna, use two open-end wrenches, one on the nut under the antenna and the other on the outer nut, to prevent the stud from turning and breaking the internal wiring.

261. Troubleshooting Test Connections

a. General. The test connections and methods of operating during troubleshooting are identical whether the unit is serviced on the pole or the test bench. On the pole, the source of 115-volt ac power is through cable W10 and fuse F401 in the RE–247/FRN–22 (fig. 16). During bench service, the 115-volt ac power is supplied through the cable fabricated in *b* below.

b. Power Cable Fabrication. Obtain a suitable length of two-wire insulated #18 AWG cable and fasten to one end a connector that will mate with the receptacle of the shop source of 115 volts ac. Solder the opposite ends to pins A and B of an AN3106A-16S-4S (same as P11 on cable W10, fig. 16).

c. Use of Test Connections. When the servicing is performed at the pole, ac power to the AN/FRA-14 may be controlled by removing and inserting plug P401 in the RE-247/FRN-22 (fig. 16) while the omnirange set is in operation. Place the ON-OFF switch on the monitor in the OFF position during all tests, if the omnirange set is to remain in operation. Remove plug P9 from receptacle J1 on the monitor. Open the rear door of the CY-1897/FRN-22, install two interlock jumpers in interlocks S801 and S802, and make all connections required to supply input power.

262. General Troubleshooting Procedure

a. Cable Troubleshooting. Cables W7 and W10 may be checked for continuity as follows:

(1) *Cable W10.* Disconnect plug P401 at receptacle J405 (fig. 16) of RE-247/FRN-22 (plug P11 connected to the AN/FRA-14) and measure the resistance with multimeter leads between pins A and B. Resistance should be 550 to 600 ohms. Measure from either pin A or B to earth ground; resistances should be infinite.

(2) *Cable W7.* Disconnect plug P9 at receptacle J1 of the monitor (plug P401 at the RE-247/FRN-22 removed) and measure resistance from center pin of plug P9 to the shell. Resistance should be 4,700 ohms ±10 percent. Check resistance to earth ground for possible shorts.

b. AN/FRA-14 Troubleshooting.

(1) Refer to figure 170 and make voltage measurements with power supplied from the 115-volt ac source to receptacle J1 of the AN/FRA-14. Voltages are taken with the multimeter with no signal input.

(2) Refer to figure 170 and measure tube socket resistance with no external connections to receptacles J1 or J2.

(3) Measure transformer T1 (fig. 204) resistances listed below with tube V1 removed and no external connection to receptacles J1 or J2.

Transformer terminals	Resistance (ohms)
1-2	550 ±20 percent.
3-4	5 ±20 percent.

(4) Inspect antenna, capacitor C1, and inductor L1 for mechanical condition. Check antenna insulators for cracks and examine other parts closely for evidence of moisture. Repair as required.

c. Overall Operational Check.

(1) Connect plugs P10 and P11 to the AN/FRA-14 mounted in its normal operating position and connect plug P401 to receptacle J405 at the RE-247/FRN-22.

(2) Use the multimeter to measure the output. Set the FUNCTION switch to DIRECT POSITION, use the 2.5 volt range (20,000 OHMS PER VOLT DC), connect the positive lead to the center contact of plug P9, and the negative lead to the plug shell.

(3) With circuit breaker K1003 on the antenna pedestal closed, but neither omnirange equipment energized, check the V1 contact potential. If over 0.1 volt, replace V1.

(4) Energize equipment No. 1 or No. 2; the multimeter should indicate a slight increase in voltage. If there is no increase in output voltage, complete the tuning procedure described in paragraph 43.

Section VI. AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20 TROUBLESHOOTING

263. General

The AM-1246/FRN-20 amplifiers, one for each transmitting equipment, are located in the CY-2274/FRN-22A, but their power supplies are located in the CY-1899/FRN-22 cabinets. For reasons of safety and accessibility, it is preferable to service the components on the test bench. Use the information in this section to obtain a complete and accurate diagnosis of the trouble. To avoid additional damage or difficulties in the unit be sure to complete the short and B+ tests (par 267*b*) and perform a thorough visual inspection before applying power. If special repair procedures are required after the trouble has been located, refer to chapter 5.

Note. The output appears across the secondary of transformer T1403 in the PP–1329/FRN–20 (fig. 240).

264. Troubleshooting Reference Data

The following list of illustrations will be useful during troubleshooting of the AM–1246/FRN–20:

Figure No.	Caption
12	Electrical Equipment Cabinet CY–2274/FRN–22A, component installation diagram.
23	Audio Frequency Amplifier AM–1246/FRN–20, tube locations.
38	Audio Frequency Amplifier AM–1246/FRN–20, control locations.
280	Audio Frequency Amplifier AM–1246/FRN–20, schematic diagram.
171	Audio Frequency Amplifier AM–1246/FRN–20, bench test setup.
172	Audio Frequency Amplifier AM–1246/FRN–20, voltage and resistance diagram.
206	Audio Frequency Amplifier AM–1246/FRN–20, interior view.
207	Audio Frequency Amplifier AM–1246/FRN–20, rear view.
208	Relay adjustment data.
292	Audio Frequency Amplifier AM–1246/FRN–20, wiring diagram.

265. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting is listed below with the applicable technical manual and the common name assigned to each.

Test equipment	Technical manual	Common name
Audio Oscillator TS–382A/U.	TM 11–2684A	AF oscillator.
Electronic Multimeter TS–505/U.	TM 11–5511	vtvm.
Electron Tube Test Set TV–2/U or.	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Oscilloscope, DuMont, Type 2559A.	----------------	Oscilloscope.
Voltmeter, Meter ME–30/U	TM 11–5132	AF vtvm.

b. Additional Equipment. Additional equipment required is listed below with its common name.

Qty	Description	Common name
1	Safety door switch (cap portion), Bryant Electric Company No. 4600A (Federal Stock No. 5938–757–4130).	Interlock jumper plug.
1	Power Supply PP–1329/FRN–20	
1	Cable, bench test, to J3	Test cable.
1	Cable, bench test, to J4	Test cable.
1	Jumper wire	Jumper.

266. Removal and Reinstallation

Although special techniques are not required in removing or replacing the AM–1246/FRN–20, care must be exercised to avoid contact with the high-voltage leads from the PP–1329/FRN–20.

a. Removal. Disconnect the 115-volt ac power supply by opening the rear door of the CY–2274/FRN–22A. Detach the plate caps from V4 and V5 (fig. 251). Disconnect the plugs from receptacles J3 and J4. Remove the trim strips and loosen the four screws at the sides of the front access panel. Withdraw the AM–1246/FRN–20 from the cabinet.

***Warning:* Before detaching the plate caps, discharge the capacitors in PP–1329/FRN–20 located in CY–1899/FRN.**

b. Reinstallation. Replace the AM–1246/FRN–20 in the cabinet, tighten the four screws on the front panel, and replace the trim strips. Attach the plate caps to V4 and V5. Make the connections at receptacles J3 and J4. If the other units in the CY–2274/FRN–22A cabinet are serviceable, 115-volt ac power may be restored to the cabinet by closing its door.

***Warning:* Insure that the PP–1329/FRN–20 in the CY–1899/FRN–22 is not operating and that its capacitors are discharged before touching the leads to V4 and V5.**

267. General Precautions

***Warning:* Power Supply PP–1329/FRN–20 furnishes 500- and 1,350-volt dc plate voltage and 230 volts ac to the AM–1246/FRN–20.**

a. Controls. Two screwdriver adjustments (R1 for LEVEL and R7 for OVERLOAD CONTROL) and a phone jack (LEVEL MONITOR, which is plugged and not used) are located behind access holes in the front panel (fig. 46). Do not change the setting of these controls during troubleshooting unless specifically told to do so.

Refer to the note in the stage-gain chart (par. 271).

b. Short and B+ Test. Before power is applied, inspect to insure that the interlock switch is serviceable, receptacles for power input and output are in working order, and that all five tubes are properly seated in their sockets. With the component disconnected, and using figure 280 as a reference, test for a short circuit in the 500-volt dc line by measuring resistance with the multimeter between receptacle J3 (fig. 206) and the chassis. An infinite value of resistance should be obtained. If a finite value of resistance is obtained, check capacitor C2 and transformers T2 and T3 for a defect before applying power.

Note. Plate caps must be installed on V4 and V5 and the clamps should be locked around their bases before power is applied.

268. Bench Test Setup

a. General. The test setup is shown in figure 171. The AF oscillator is adjusted in accordance with instructions in TM 11-2684A. The AF oscillator and the AF vtvm require 115-volt 60-cps power for operation.

b. Cable Fabrication. The connection between transformer T1403 of the PP-1329/FRN-20 and the plate caps of tubes V4 and V5 in AM-1246/FRN-20 is furnished with the PP-1329/FRN-20 (fig. 240). The connections between the AF oscillator and the AM-1246/FRN-20 and between the multimeter and the terminals of transformer T1403 are furnished with the test equipment. The connections to receptacles J3 and J4 of AM-1246/FRN-20 and a jumper, however, must be fabricated as indicated in the chart below.

Item and use	Wire size	Length
Electrical plug connector, Howard B. Jones Co. Part No. S318FHT, (Federal Stock No. 5935-295-4820) at J4.		
Electrical plug connector, James Millen Co. Part No. 37001 (plug) (Federal Stock No. 5935-259-6810) at J3.		
Plug, AN3106B-36-1S, (Federal Stock No. 5935-231-1744) at J1401 on PP-1329/FRN-20.		
Wire, connections between PP-1329/FRN-20 and J3 and J4 (amplifier and power supply separated about 2 feet).	#18 AWG----	8 ft.

c. Amplifier Power. The PP-1329/FRN-20 is used with the AM-1246/FRN-20 under normal operating conditions and is the best power source for bench testing the unit. It is not considered practicable to build a substitute that would, necessarily, be an exact duplicate of the PP-1329/FRN-20.

d. Test Procedure.

(1) Remove the AM-1246/FRN-20 from the cabinet (par. 266).

(2) Connect the AF oscillator to the AM-1246/FRN-20 and the multimeter to PP-1329/FRN-20 (fig. 171).

(3) Connect the PP-1329/FRN-20 to the AM-1246/FRN-20 at receptacles J3 and J4.

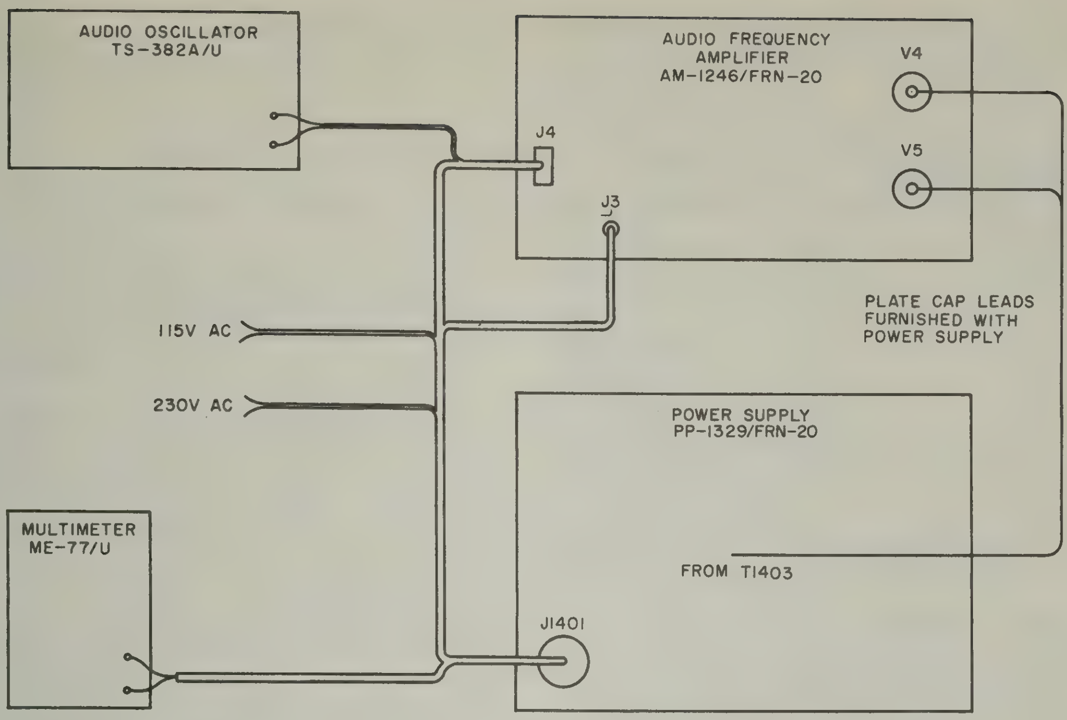
(4) Install the interlock jumper plug and the jumper.

(5) Apply 115 volts ac to pins U-V and M-N and 230 volts ac to pins G-S of J1401 in the PP-1329/FRN-20 (fig. 240).

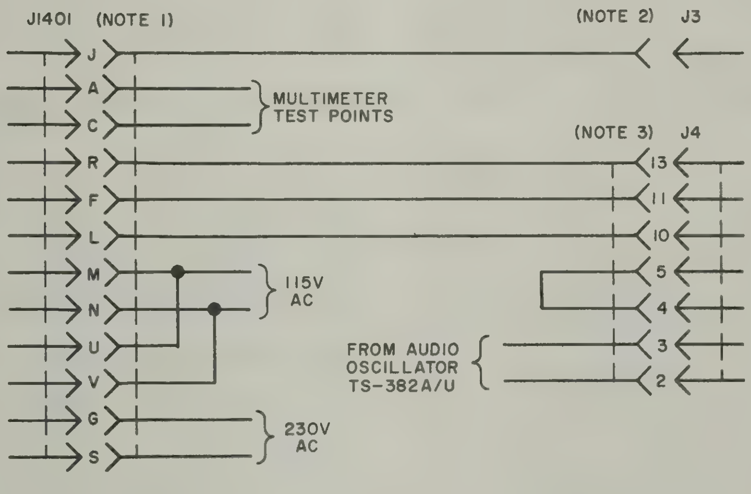
269. Localizing Troubles

a. Preliminary Operational Check. To prevent the introduction of additional troubles, check the test setup for secure and correct connections (fig. 171). Connect the AM-1246/FRN-20 to the PP-1329/FRN-20 power supply and apply the ac operating voltage. Apply a 1.5-volt signal input at terminals 2 and 3 of receptacle J4 (fig. 206) and, after a warm-up period, check for such defects as an overheated transformer, smoking components, cold tubes, blown fuses in the PP-1329/FRN-20 and chattering in overload relay S2. If there is no output from relay K901 in the O-371/FRN-20 (fig. 211) when in the cabinet but if it functions properly on the test bench the AM-1246/FRN-20 (fig. 207) may not be shorting bias resistor R6 in the amplifier. (Resistor R6 is shorted out in the test setup.)

b. Use of Chart. To use the chart, check the *Indication* column for the trouble symptoms observed, note the probable troubles that may exist, and apply the corrective procedure given for that trouble, observing all paragraph references.



A. TEST CONNECTIONS



B. CABLE FABRICATION

NOTES

1. CONNECTOR, PLUG, AN3106B-36-1S (SAME AS PLUG P1808)
2. CONNECTOR, HV TYPE, 1 PIN J. MILLEN CO. #37001 (SAME AS PLUGS P1910 AND P1914).
3. CONNECTOR, PLUG, H.B.JONES CO. # S318FHT (SAME AS PLUGS P1909 AND P1913)
4. CABLE LENGTH AS REQUIRED, USE #18 AWG STRANDED WIRE

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Figure 171. Audio Frequency Amplifier AM–1246/FRN–20, bench test setup.

c. Audio Frequency Amplifier AM–1246/FRN–20, Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	Filaments of V1, V2, and V3 do not light.	Defective transformer T4	Check T4 (par. 272).
2	Filaments of tubes V4 and V5 do not light.	Defective transformer T5	Check T5 (par. 272).
3	No output	Defective stage	Make signal tracing test to localize the stage (par. 270). Make voltage and resistance measurements (par. 272).
4	Low output	Defective stage	Make stage-gain measurements (par. 268). Make voltage and resistance measurements (par. 272). Check adjustment of R1 (fig. 207).
5	Distorted output	Defective stage	Make signal tracing test. Use the oscilloscope to localize the stage causing distortion (par. 273*c*). Isolate defective part by substitution (par. 273).

270. Signal Tracing

a. General. Signal tracing is used to locate a defective stage, especially when there is no output. If the unit has low output, use stage-gain procedures (par. 271).

b. Procedure. Connect the equipment (fig. 171), and adjust the AF oscillator to 1.5 volts at 60 cps. After a warmup period, connect the AF vtvm across the test points indicated in the chart below, in the order of steps given, to determine the defective stage (the test point where the normal reading is not obtained).

Step	Input connections	Input (v ac)	Test points	Normal reading (v ac)
1	2 and 3 of J4	1. 5	Pins 1 and 4 of V1 (fig. 207).	0. 6
2	2 and 3 of J4	1. 5	Pins 3 of V2 and V3.	11
3	2 and 3 of J4	1. 5	Pins 3 and 4 of V4 and V5.	28
4	2 and 3 of J4	1. 5	Plates of V4 and V5.	1, 500
5	2 and 3 of J4	1. 5	Secondary of T1403 (fig. 240).	115

271. Stage Gain

Use the procedures below to locate a defective stage when the output is low.

a. Connect the equipment as shown in the test setup (fig. 171), apply power, and allow the system to warm up.

b. Stage gains for the indicated inputs and test connections are shown in the following chart. Observe the note in the chart below before making measurements. Apply the inputs, take measurements at the indicated test points in the order given, and calculate stage gains. If gains are low, check the applicable tube (par. 227), voltages and resistances (par. 272*a*), and transformer dc resistances (par. 272*b*).

Step	Input connections	Input (v ac)	Test points	Stage gain
1	3 and 4 of V4 and V5.	28	T1403 secondary	4. 1
2	3 of V2 and V3	11	T1403 secondary	10. 4
3	1 and 4 of V1	0. 6	T1403 secondary	191
4	2 and 3 of J4	1. 5	T1403 secondary	76. 6

Note. Place the LEVEL control (R1) in the full clockwise position and the OVERLOAD control (R7) in the normal operating position.

272. Isolating Trouble

a. Voltage and Resistance Measurements. Before using figure 172, contained in separate envelope, read the notes carefully in order to set up the test conditions which must be duplicated to obtain valid measurements. The voltage and resistance measurements in figure 172 are used to isolate faulty parts after a defective stage has been located. When the defective part is located, check associated parts to determine whether another part caused the failure. (A shorted capacitor can overload an associated resistor.)

b. Transformer Resistance. The dc resistances in the chart below are used to isolate a transformer that is open or shorted. Connect the ohmmeter test prods across the terminals shown.

Transformer	Terminals	Resistance (ohms)
T1 (fig. 206)	1–4	45.
	3–6	45.
	7–9	1,400.
	8–10	1,400.
T2 (fig. 206)	P–B	785.
	P–P	1,570.
	G–C	1,000.
	G–G	2,000.
T3	1–2	85.
	1–3	170.
	4–5	16.
	4–6	32.
T4	0–230	183.
	Across 6.3-volt winding	Less than 1.
	Across 6.3-volt winding	Less than 1.
T5	0–230	18.
	Across 10-volt winding	Less than 1.

273. Additional Troubleshooting Data

a. Tube Substitution. Under unusual circumstances, and even though tubes may have been tested with the tube tester, it may be necessary to resort to tube substitution (one or more tubes) to be certain that a tube is not the cause of trouble in a defective stage. Never leave a new tube in the socket if the unit operates satisfactorily with the original tube.

***Warning:* Before removing V4 and V5, use a tool with an insulated handle to short their plate caps to the chassis.**

b. Parts Substitution. Another procedure to use for hard-to-find difficulties is the substituting of parts that are known to be functioning properly for suspected parts. Be sure to disconnect the suspected part before connecting the temporary part. Do not leave the new part in the unit unless it corrects the difficulty.

c. Other Information. If replacement of capacitor C2 does not correct a distorted signal, refer to the instruction book for use of the oscilloscope (par. 265) in locating the trouble. Substitute the oscilloscope for the AF vtvm at the test points used in signal tracing (par. 269) or stage-gain measurements (par. 271). Synchronize the horizontal sweep of the oscilloscope at 30 cps, and use the vertical deflection amplifier input at the signal tracing or stage-gain test points.

d. Repair and Test. For instructions on special techniques to be used in repair of the amplifier, see chapter 5. For the final test procedures, refer to chapter 6.

Section VII. AUDIO FREQUENCY AMPLIFIER AM–1247/FRN–20 TROUBLESHOOTING

274. General

The AM–1247/FRN–20 should be serviced with the bench test setup described in this section. For accessibility it is impracticable to attempt the work in the cabinet. Use all information in this section in the order given to provide a complete, quick, and accurate diagnosis of the faulty unit. Always complete the short and B+ checks contained in this section and perform a thorough visual inspection before applying power to avoid further damage to the unit. When the trouble has been located, refer to the appropriate paragraph of chapter 5 for any special repair procedures.

275. Troubleshooting Reference Data

The following list of illustrations on chart will be useful during troubleshooting of the AM–1247/FRN–20.

Fig. No.	Caption
5 (TM 11–5825–205–12).	Electrical Equipment Cabinet CY–1826/FRN–20, front view with components installed.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
26	Audio Frequency Amplifier AM–1247/FRN–20, tube, fuse, and control locations.
287	Audio Frequency Amplifier AM–1247/FRN–20, schematic diagram.
173	Audio Frequency Amplifier AM–1247/FRN–20, bench test setup.
174	Audio Frequency Amplifier AM–1247/FRN–20, voltage and resistance diagram.
209	Audio Frequency Amplifier AM–1247/FRN–20, interior view.
210	Audio Frequency Amplifier AM–1247/FRN–20, rear view.
294	Audio Frequency Amplifier AM–1247/FRN–20, wiring diagram.

276. Equipment Required

a. Test Equipment. The test and other equipment required for troubleshooting is listed below with the applicable technical manual and common name assigned to each.

Test equipment	Technical manual	Common name
Audio Oscillator TS-382A/U.	TM 11-2684A	AF oscillator.
Electronic Multimeter TS-505/U.	TM 11-5511	vtvm.
Electron Tube Test Set TV-2/U or	TM 11-2661	TV-2/U.
Electron Tube Test Set TV-7/U.	TM 11-5083	TV-7/U.
Oscilloscope, DuMont, type 2559A.		Oscilloscope.
Multimeter ME-77/U	TM 11-6625-203-12.	Multimeter.
Voltmeter, Meter ME-30A/U.	TM 11-5132	vtvm.

b. Additional Equipment. The additional equipment required to troubleshoot the AM-1247/FRN-20 is listed below with its common name.

Qty	Description	Common name
1	Resistor, 500-ohm, 2-watt ±10%	Dummy load.

277. Removal and Reinstallation

Special techniques are not required for removal or reinstallation of the AM-1247/FRN-20 and its component parts. Contact with the 115-volt power, however, must be avoided.

a. Removal. Disconnect the power supply cable W22 from the 115-volt ac wall outlet. Loosen the two screws near each end of the front access panel (total of four screws). Withdraw the AM-1247/FRN-20 from the remote control cabinet far enough to disconnect power cable W22 at J3, input cable W20 at J1, and output harness W21 at J2 (fig. 16). The AM-1247/FRN-20 may then be completely withdrawn from the cabinet.

b. Reinstallation. Insert the AM-1247/FRN-20 halfway into the cabinet. Connect input cable W20 at J1, output harness W21 at J2, and power cable W22 at J3. Thread the other end of cable W22 through the slot at the lower rear portion of the cabinet. Push the AM-1247 to the rear of the cabinet and tighten the four screws at the ends of the panel.

***Warning:* Do not connect the power cable to the wall outlet until ready to put the entire cabinet into service.**

278. General Precautions

***Caution:* Do not apply high-level audio input signals to receptacle J1 unless the AM-1247/FRN-20 output is connected to its normal or dummy load. Make all resistance measurements with all external connections removed, and momentarily short resistance measurement points together before measuring resistance to protect the multimeter from charged capacitor voltages.**

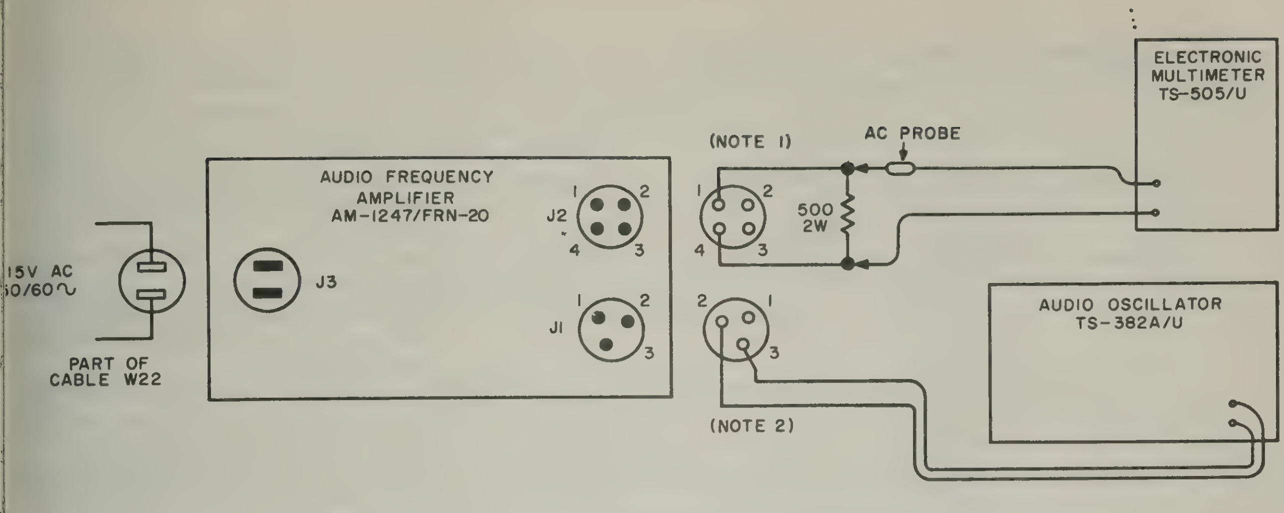
a. Controls. Do not change the settings of input level control R1 or threshold level control R16 unless specifically instructed to do so (fig. 26).

b. Short and B+ Test. Perform the preliminary short and B+ check with the multimeter as shown in the chart below. Refer to the technical manual for the multimeter for correct operating procedure.

Measurement points	Nominal resistance (ohms)	Abnormal indication	Corrective measure
Between junction of C7, L2, and R15 and chassis (fig. 253).	200K (±20%)	Zero resistance	Check C7 for short.
		Low resistance	C7 leaky, C8 shorted or leaky, transformers T2, T3, and T4 shorted.
		High resistance	R2, R3, R4, R15, or R16 open.

279. Bench Test Setup

a. Connect the AM-1247/FRN-20 and test equipment as shown in figure 186. Adjust the oscillator in accordance with instructions in TM 11-2684A. The AF oscillator, AF vtvm, and the AM-1247/FRN-20 will require a source of 115-volt, 60-cps power for operation during troubleshooting.


ELECTRONIC MULTIMETER TS-505/U
(NOTE 1)
AC PROBE
AUDIO FREQUENCY AMPLIFIER AM-1247/FRN-20
J2
J3
J1
500 2W
15V AC
50/60∿
PART OF CABLE W22
AUDIO OSCILLATOR TS-382A/U
(NOTE 2)

NOTES
1. CONNECTOR PLUG, (AMPHENOL) 91MC4M (SAME AS PLUG P2)
2. CONNECTOR PLUG, (AMPHENOL) 91MC3M (SAME AS PLUG P1)
3. USE #20 AWG STRANDED WIRE FOR CONNECTIONS .

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Figure 173. Audio Frequency Amplifier AM–1247/FRN–20, bench test setup.

b. Use a male plug, American Phenolic Co. part No. 91MC4M (same as P2 in fig. 16) and make up the test plug by connecting the 500-ohm 2-watt output load resistor between terminals 1 and 4. Use male plug, American Phenolic Co. part No. 91MC3M (same as P1), and make up a test plug by soldering two 3-inch pieces of wire to contacts 1 and 3 to connect the audio oscillator. The cord supplied with the AM–1247/FRN–20 is used to connect it to the power source.

280. Localizing Troubles

a. General. The troubleshooting procedures for the AM–1247/FRN–20 are divided into three sections: power supply, amplifier stages, and agc stages. Further procedure localizes the defective stage and isolates the defective part. Unusual or elaborate procedures are fully described in the paragraph reference given in the troubleshooting chart.

b. Preliminary Operational Check. When the bench test setup connections are completed (par. 280), energize the AM–1247/FRN–20 and test equipment. Allow warmup time while visually checking for possible conditions which require correction before performing the troubleshooting procedures. Adjust the AF oscillator output for 1 millivolt at 1,000 cps, and remove V5 from its socket for all tests in the chart unless otherwise specified. Normally, the output signal from the AM–1247/FRN–20 will be 1.8 volts ac.

c. Use of Chart. Review each item in the order given. If previous operational information indicates the early steps of the chart are normal, proceed to the step where the first doubtful condition occurs. When in doubt, start with the first step. Check the indications against the *Indication* and *Probable trouble* columns, and then follow the procedure outlined in the *Procedure* column to eliminate the probable causes one by one. Carefully observe all figure and paragraph references to insure a complete check of each item.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	Filaments do not light	Blown fuse	Check fuse F1 (fig. 210). Check transformer T5 (par. 283).
2	No signal output with V5 removed.	No B+	Check V7. Make voltage and resistance measurements at V7 (fig. 174).
		Defective amplifier stage	Make signal tracing check (par. 281). Make voltage and resistance measurements (fig. 174).
3	Low signal output with V5 removed.	Defective amplifier stage	Make stage-gain measurements (par. 282). Make voltage and resistance measurements of defective stage (fig. 174).
4	Distorted signal output	Defective amplifier stage	Make stage-gain or signal-tracing checks, using oscilloscope (par. 284*c*).
5	Low or no output with tube V5 installed.	Defective agc stage	Check tube V5. Make voltage and resistance measurements at V5 (fig. 174). Check resistor R17 (fig. 209). Check capacitor C6 by substitution. Check transformer T4 (par. 283). Check adjustment of R16 (par. 88).
6	High signal output with V5 installed.	Defective agc amplifier	Check V6. Make voltage and resistance measurements at V6 (fig. 174). Check V5. Make voltage and resistance measurements at V5 (fig. 174).

281. Signal Tracing

a. Signal tracing is a quick and effective method by which a defective stage may be located in the AM–1247/FRN–20 when there is no output signal. If a weak signal passes through, and can be indicated on the AF vtvm across the dummy load, use stage-gain measurements (par. 282) instead of signal tracing methods.

b. Make connections as outlined in paragraph 279 and adjust the AF oscillator for 1,000 microvolts at 1,000-cps. When the equipment has stabilized, connect the common lead of the AF vtvm to the chassis and the other lead to the tube socket pin indicated in the *Test point* column of the chart. Tube V5 must be removed from the socket during signal tracing. Start with step No. 1 and progressively check through each step; the point where no signal is available indicates the defective stage. When the stage is located, return to the troubleshooting chart (par. 280) for further isolation procedures.

Step No.	Test point	Stage checked
1	Pin 3, V1 (fig. 209)	Input ampl V1.
2	Pin 3, V2	Input ampl V2.
3	Pin 2, V3	2d ampl V3.
	Pin 5, V3	
4	Pin 2, V4	Output ampl V4.
	Pin 5, V4	
5	Pin 3, V5	Agc ampl V6.
	Pin 5, V5	

282. Stage Gain

a. Use these stage-gain troubleshooting procedures to locate the defective stage in a weak AM–1247/FRN–20. Connect the equipment as instructed in paragraph 279 but do not connect the AF oscillator. Apply power to all equipment and turn both controls R1 and R16 (fig. 210) fully clockwise (shaft end view). Remove V5 from the socket.

b. Connect the AF oscillator as indicated in step 1 of the chart below and set for 1,000 cps. Adjust the AF oscillator output for an AF vtvm reading of 2.0 volts ac across pins 1 and 4 of receptacle J2. Note the output and compare it with the chart. Proceed through the steps until more than normal voltage is required to obtain a 2.0-volt ac output. This will indicate the defective stage.

Step No.	AF oscillator connected to	AF oscillator output (volts)	Stage gain
1	Pins 1 and 4 of V4 (fig. 209)	1. 09	1. 8
2	Pins 1 and 4 of V3	0. 055	19. 8
3	Pins 8 of V1 and 8 of V2	0. 012	4. 5
4	Pins 2 and 3 of J1	0. 0008	15. 4

c. Check the automatic gain control section of the AM–1247/FRN–20 by inserting V5 and connecting the equipment as shown in figure 173. Set the AF oscillator for an output of 0.0008 volt at 1,000 cps and adjust threshold control R16 (fig. 26) to reduce the amplifier output to 1.73 volts ac on the AF vtvm. Gradually increase the af oscillator output to 1.7 volts; the AM–1247/FRN–20 output should not exceed 3.2 volts ac. If the output is not held to limits, trouble is in agc amplifier V6 and/or agc detector V5.

283. Isolating Trouble

a. Voltage and Resistance Measurements. When the defective stage is located, make voltage and resistance measurements and compare the values obtained with those shown in figure 174, contained in separate envelope to aid in isolating the defective component parts. When a defective part is found, check further to determine whether another part caused the failure. *Example:* if a resistor is open, check for a shorted capacitor or an overload condition. Observe all the notes in figure 174 for test conditions.

b. Transformer and Reactor Resistance. The data listed in the chart below will be useful in isolating defective transformers and reactors. In addition to checking the resistance values shown in the chart, check the resistance between windings. Any resistance readings below infinity at these points indicate internal leakage, and the part should be replaced.

Transformer or reactor	Connection points	Resistance (ohms)
L1 (fig. 209)	Reactor leads	300
L2 (fig. 209)	Reactor leads	1, 312
T1 (fig. 210)	Brn-yel	30
	Red-grn	10
	Red-yel	20
	Orn-blu	30
	Orn-grn	20
	Grn-blu	10
	Vio-wht	2, 400
	Vio-gy	1, 200
	Gy-wht	1, 200
T2 (fig. 210)	G–C	6, 500
	G–G	13K
	P–B	775
	P–P	1, 550
T3 (fig. 210)	1–2	1, 250
	1–3	2, 500
	4–5	30
	4–6	60
T4 (fig. 210)	G–C	6, 500
	G–G	13K
	P–B	775
	P–P	1, 550
T5 (fig. 210)	Blk-blk	5
	Red-red yel	115
	Red-red	230
	Yel-yel	Less than 1
	Grn-grn yel	Less than 1
	Grn-grn	Less than 1

284. Additional Troubleshooting Data

a. Tube Substitution. Although tubes of the AM–1247/FRN–20 may have been tested previously in the tube tester, it may be necessary to resort to tube substitution to be absolutely certain that tubes are not the cause of the trouble. Do not leave new tubes in if substitution does not correct the trouble.

b. Parts Substitution. Parts substitution may also reveal the defective part when other tests fail. Always disconnect the suspected part before temporarily installing the substitute part. Do not leave the substitute part in unless it corrects the trouble.

c. Other Information. Use of the oscilloscope at the same test points as the AF vtvm during signal-tracing or stage-gain checks is advantageous when troubleshooting for distortion. Consult the oscilloscope instruction manual. Use the vertical deflection amplifier input at the test points and synchronize the horizontal oscilloscope sweep at 500 cps.

d. Repair and Test. Refer to chapter 5 for special repair techniques and to chapter 8 for final test procedures.

Section VIII. AUDIO FREQUENCY OSCILLATOR O–371/FRN–20 TROUBLESHOOTING

***Warning:* High voltages are present in this component. Be careful when working inside the chassis. Avoid physical contact with exposed terminals and parts. Use standard safety precautions when measuring high voltages.**

285. General

a. The O–371/FRN–20 supplies a 50- or 60-cps audio voltage to AM–1246/FRN–20, which amplifies it to a level sufficient to operate the goniometer motor. When the main power source for the omnirange equipment has a frequency of 50 cps, this oscillator is adjusted to furnish a 60-cps signal to the AM–1246/FRN–20. When the power source frequency is 60 cps, the oscillator output is adjusted to deliver a 50-cps signal. There are two O–371/FRN–20 oscillators in the omnirange set (one for each equipment).

b. The O–371/FRN–20 can be serviced in the cabinet, but removal and troubleshooting at the test bench is recommended for safety and convenience.

286. Troubleshooting Reference Data

The following list of illustrations will be useful during troubleshooting.

Fig. No.	Caption
12	Electrical Equipment Cabinet CY–2274/FRN–22A, component installation diagram.
22	Audio Frequency Oscillator O–371/FRN–20, tube, fuse, and thermal relay locations.
37	Audio Frequency Oscillator O–371/FRN–20, control locations.
279	Audio Frequency Oscillator O–371/FRN–20, schematic diagram.
175	Audio Frequency Oscillator O–371/FRN–20, bench test setup.
176	Audio Frequency Oscillator O–371/FRN–20, voltage and resistance diagram.
211	Audio Frequency Oscillator O–371/FRN–20, exterior view.
212	Audio Frequency Oscillator O–371/FRN–20, interior view.
213	Audio Frequency Oscillator O–371/FRN–20, rear view.
295	Audio Frequency Oscillator O–371/FRN–20, wiring diagram.

287. Equipment Required

a. Test Equipment. Test equipment required for troubleshooting is listed below with the applicable technical manual and common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Electronic Multimeter TS–505/U.	TM 11–5511	vtvm.
Frequency Meter FR–67/U.	TM 11–2698	Frequency meter.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment. The additional equipment required is listed below with its comman name.

Qty	Description	Common name
1	Tool Equipment TE–113	Tool kit.
1	Bench test cable (par. 290)	Test cable.
1	Connector, Plug—H. B. Jones No. P410 CCT (Federal Stock No. 5935–258–4820).	Output plug.
1	Connector, Plug—H. B. Jones No. S410 CCT (Federal Stock No. 5935–231–8185).	Power plug.
1	500-ohm 2-watt resistor ±20%.	Output load resistor.
2	500,000-ohm 2-watt resistors	Control voltage load resistors.
2	0.5-microfarad, 400-volt capacitors (type not critical).	Blocking capacitors.

288. Removal and Reinstallation

a. Removal. Refer to figure 16 and remove plugs P1907 and P1908 or P1911 and P1912, depending on which equipment (No. 1 or No. 2) is being serviced. Remove the cabinet trim strips (fig. 11) and the four chassis mounting screws. Withdraw the O–371/FRN–20 from the cabinet.

b. Reinstallation. Replace the O–371/FRN–20 in the cabinet and tighten the four chassis mounting screws. Replace the cabinet trim strips and connect plugs P1907 and P1908 or P1911 and P1912 to the appropriate receptacle (fig. 16).

289. General Precautions

a. Do not change the settings of the OSC FREQ or REGULATOR controls unless specifically instructed to do so in this section.

b. Before applying power to the component, inspect it visually to insure that receptacles for power input and output are in working order and that all tubes are properly seated in their sockets. With the O–371/FRN–20 disconnected, and using figures 279 and 213 as a reference, test for a short circuit in the B+ circuit by measuring with the multimeter between the point indicated in the following chart and chassis ground.

Measurement points	Resistance (ohms)	Procedure
Junction of L902 and C912 to chassis.	50K	If resistance varies more than 20 per cent, check C905, C911, C912, R907, R918, R920, R921, R923, and R924.
Pin 1 of V905 to chassis (fig. 211).	50K	
Pin 6 of V901 to chassis.	1.1 meg	

c. When a part has failed, be sure to check the associated parts. They may be responsible for the failure or may have become defective as a result of the failure.

d. Correct all known defects *before* applying power. Do not apply power if there are indications that energizing the unit will cause additional damage.

e. When troubleshooting the O–371/FRN–20 in the cabinet, interlocks S1903 and S1904 (fig. 227) must be disabled with jumper plugs. Be extremely careful when working in cabinets where interlocks are disabled, because they will no longer protect personnel from high voltages.

290. Bench Test Setup

a. General. Connections for bench testing the O–371/FRN–20 are shown in figure 175. Power sources required are listed below. Each is to be provided with adequate switching facilities to control application of power.

(1) A 230-volt 50- or 60-cps ac source.

(2) A 50- or 60-cps ac source, capable of being varied from 95 volts to 130 volts.

(3) A 115-volt 50- or 60-cps ac source. This voltage is needed only to test relay circuits and need not be applied during other bench test procedures.

b. Cable Fabrication. Connecting leads for the multimeter, vtvm, and frequency meter are furnished with the test equipment. The test cables for the O–371/FRN–20 must be fabricated as indicated in B, figure 175.

c. Additional Test Connections. Make the following additional test connections before starting the troubleshooting procedures.

(1) Provide a suitable mounting for the two 500,000-ohm 2-watt resistors and the two 0.5 microfarad capacitors.

(2) Join the resistors and capacitors in a series string with the two resistors in the center.

(3) Connect the free ends of the two capacitors to the variable ac voltage source.

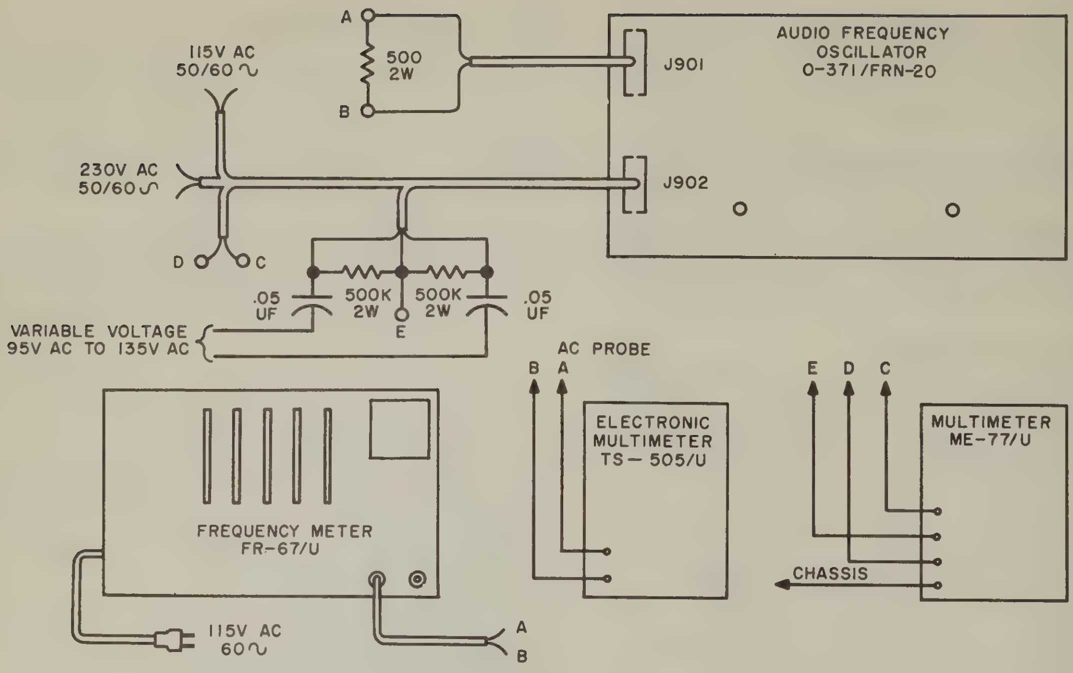
291. Localizing Troubles

a. As a preliminary step, all tubes should be tested.

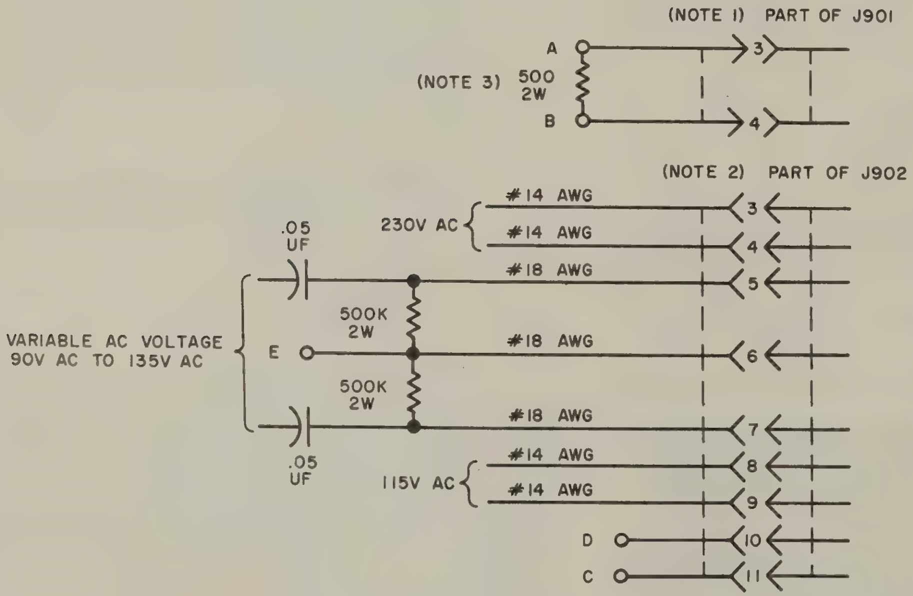
b. Make a preliminary operational check before going into the troubleshooting procedures. With bench test connections made according to figure 175, apply the 230-volt ac power and the 115-volt ac relay voltage. Be alert for signs of overload, such as fuses blowing and burning sounds or smells; *shut off power immediately* if there are such signs.

c. During operational testing, observe relay operation. Thermal relay K902 (fig. 211) should operate 51 to 69 seconds after the relay voltage is applied. Motor control relay K901 (fig. 211) should operate immediately after K902 operates.

d. The procedures in the following troubleshooting chart will localize trouble to a stage. Isolation of the defective part within that stage is covered in paragraphs 292 and 293.



A. TEST CONNECTIONS



B. CABLE FABRICATION

NOTES

1. CONNECTOR, PLUG, HB JONES #P410CCT (SAME AS PLUGS P1907 AND P1911)
2. CONNECTOR, PLUG, HB JONES #S410CCT (SAME AS PLUGS P1908 AND P1912)
3. ALPHABETICAL DESIGNATIONS DENOTE TEST POINT CONNECTIONS.
4. CABLE LENGTH AS REQUIRED.

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Figure 175. Audio Frequency Oscillator O-371/FRN-20, bench test setup.

Item	Indication	Probable trouble	Procedure
1	No signal output	No B+ from power supply	Check tubes and fuses (fig. 213). Check L902 resistance (par. 294*b*). Check L901 resistance (par. 294*b*). Check C912 leakage. Check C911 leakage. Check T902 (par. 294*b*).
		Trouble in agc detector V906 stage.	Remove V906 from its socket. If this restores signal, check regulator V905 output. If removing V906 from socket does not restore signal, check voltage and resistance of agc detector V906 stage (fig. 176).
		Trouble in control amplifier V903 stage.	If removing V906 from socket does not restore signal and agc detector circuit checks normal, check voltage and resistance of control amplifier V903 (fig. 176).
		Trouble in oscillator V902 stage.	If the control amplifier circuit checks normal, make voltage and resistance measurement of oscillator and oscillator detector (V902) circuits (fig. 176).
2	Low signal output	Low B+ voltage	Check C912 for leakage. Check C911 for leakage. Check T902 for open secondary (fig. 176).
		Trouble in agc detector V906	Remove agc detector tube V906 from socket. If removing V906 raises signal output, check voltage and resistance of V906 (fig. 176). If V906 checks normal, check regulator V905 voltage and resistance (fig. 176).
		Trouble in control amplifier V903.	If removing V906 from socket does not raise signal output, check V906 voltage and resistance (fig. 176).
		Trouble in oscillator V902 stage.	If V906 checks normal, check oscillator cathode follower V902 voltage and resistance (fig. 176). If V902 checks normal, check V902 voltage and resistance (fig. 176).
3	High signal output	Trouble in voltage regulator V905.	Check V905 voltage and resistance (fig. 176).
		Trouble in agc detector V906	Check V906 voltage and resistance (fig. 176).
4	No change in output voltage with variation in variable ac input.	Agc circuit not functioning	Check V906 and resistance (fig. 176).
5	Relay circuits do not function	Thermal relay K902 defective	Apply 115-volt ac relay voltage to terminals 8 and 9 of J902 (fig. 213). After delay of 51 to 69 seconds measure voltage at coil terminals of K901 (fig. 211). If voltage is absent, replace K902.
		Motor control relay K901 defective.	If voltage is present, check winding of K901 (fig. 214). If the winding is normal, check contact adjustment of K901 (fig. 214).

292. Signal Tracing

a. The procedures given in the troubleshooting chart can be augmented by signal tracing with the vacuum-tube voltmeter to localize a defective stage. Make connections as shown in figure 175 and use the vtvm at the points listed below on ac voltage ranges.

b. The following table gives the signal voltages that are normal at the important points of measurement in signal circuits.

Points of measurement	Ac volts
V901 (fig. 211) grid (pin 1) to chassis	0. 42
V902 grid (pin 2) to chassis	1. 0
V901 plate (pin 5) to chassis	22. 0
V902 grid (pin 7) to chassis	20. 0
V902 cathode (pin 8) to chassis	18. 5
V903 grid (pin 1) to chassis	1. 7
V903 plate (pin 5) to chassis	7. 9

293. Isolating Trouble

a. The voltage and resistance diagram of the O–371/FRN–20 is given in figure 176, contained in separate envelope which includes notes on measurement procedures. These measurements will narrow the search for a defective part within a stage where trouble has been localized by procedures in the troubleshooting chart. Once a faulty portion of the circuit is located by voltage and resistance measurement, each part included in that portion of the circuit can be checked individually, following the schematic diagram (fig. 279).

b. Transformer and reactor dc resistances are given in the following chart, and each component should be completely isolated to measure the resistance.

Transformer or inductor	Connection points	Resistance (ohms)
L901 (fig. 213)	Across leads	190
L902	Across leads	190
T901	1–2	200
	3–4	24
T902	1–2	10
	3–4	10
	5–7	Less than 1
	9–10	155
	9–11	310
	8–12	Less than 1

294. Additional Troubleshooting Data

a. Although the tubes have been tested as a preliminary to troubleshooting, occasionally a tube which tests satisfactory may still be responsible for faulty operation. When this condition is suspected, substitution of tubes may clear up the trouble.

(1) If there is reason to suspect a particular tube, a direct substitution may be made.
(2) If no indications point to a particular tube, a complete new set of tubes may be substituted. If this clears up the trouble, replacement of the old tubes, one at a time, will eliminate the faulty tube.
(3) When substituting tubes, replace all original tubes which do not affect performance.

b. A part which tests normal may still be responsible for faulty operation. Where this condition is suspected, use the following part substitution procedure.

(1) Disconnect the suspected part from the circuit and temporarily substitute a replacement of the same value.
(2) If the replacement restores correct operation, make the replacement permanent. If not, remove the substituted part and restore the original part to the circuit.
(3) When substituting parts, *always* use a replacement part of the same electrical value, tolerance, and rating as the original, and as near the same physical size as possible.

c. Before returning the component to service, make a quick voltage and resistance check, an operational test (par. 290), and a final test in accordance with chapter 6.

Section IX. AUDIO FREQUENCY OSCILLATOR O–373/FRN TROUBLESHOOTING

***Warning:* The O–373/FRN circuit is energized with high voltage. Avoid physical contact with exposed parts and terminals. Use standard safety precautions when measuring high voltages.**

295. General

a. The O–373/FRN supplies a 1,000-cycle audio tone to the modulator of the transmitter through the keyer for transmission of the keyed identification signal. There are two O–373/FRN oscillators in the omnirange set, one for each equipment.

b. The O–373/FRN may be serviced in place, but servicing at the test bench is recommended for safety and convenience.

296. Troubleshooting Reference Data

The following list of illustrations on chart will be useful in troubleshooting.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
25	Audio Frequency Oscillator O–373/FRN, tube, fuse, and control locations.
283	Audio Frequency Oscillator O–373/FRN, schematic diagram.
177	Audio Frequency Oscillator O–373/FRN, bench test setup.
178	Audio Frequency Oscillator O–373/FRN, voltage and resistance diagram.
215	Audio Frequency Oscillator O–373/FRN, interior view.
216	Audio Frequency Oscillator O–373/FRN, rear view.

297. Equipment Required for Troubleshooting

a. Test Equipment. Test equipment required for troubleshooting the O–373/FRN is listed below with the applicable technical manual and common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Spectrum Analyzer TS–723A/U.	TM 11–5097	Spectrum analyzer.
DuMont Model 2559A Oscilloscope (or equivalent).	----------------	Oscilloscope.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment. Additional equipment required is listed below with its common name.

Qty	Description	Common name
1	Two-wire power cable, fitted with male and female plugs.	Power cable.
1	Male plug, Amphenol 91–MC4M. (Federal Stock No. 5935–376–9307).	Test plug.
1	500-ohm 2-watt resistor	Output load.
1	Shielded test lead with a banana plug on one end.	Test lead.

298. Removal and Reinstallation

a. Removal. To remove the O–373/FRN chassis from the cabinet, use the following procedure.

(1) Disconnect plugs P814 (P816 in equipment No. 2) and P811 (P812 in equipment No. 2) (fig. 16).
(2) Remove the cabinet trim strips.
(3) Remove the chassis mounting screws that hold the chassis in place.
(4) Withdraw the chassis from the cabinet.

b. Reinstallation. To replace the O–373/FRN, use the following procedure.

(1) Place the chassis in the cabinet opening.
(2) Replace the chassis mounting screws.
(3) Replace the cabinet trim strips.
(4) Reconnect plugs P814 (or P816) and P811 (or P812).

299. General Precautions

a. Control R15 (fig. 216) may be left in operating position, but shorting plug P1 *must* remain connected to J3 at all times.

b. Use the multimeter resistance scale and trace the B+ line for possible open and short circuits at the points listed below before applying power.

Measure between points	Resistance (ohms)
Junction of L3 and C9 to chassis (fig. 215)	22K
Junction of R6 and C7 to chassis	19K
Junction of L1 and C3 to chassis	20K

c. Visually inspect the equipment and repair any defects discovered.

d. When a part is found to be faulty, check associated parts which may have been overloaded as a result of its failure.

300. Bench Test Setup

a. Connections for bench testing the O–373/FRN are shown in figure 177. The tests consist of the measurement of output voltage, output frequency, and a check for waveform distortion.

b. Bench testing requires a source of 115 volts, 50 or 60 cps ac, with adequate switching to control the application of power.

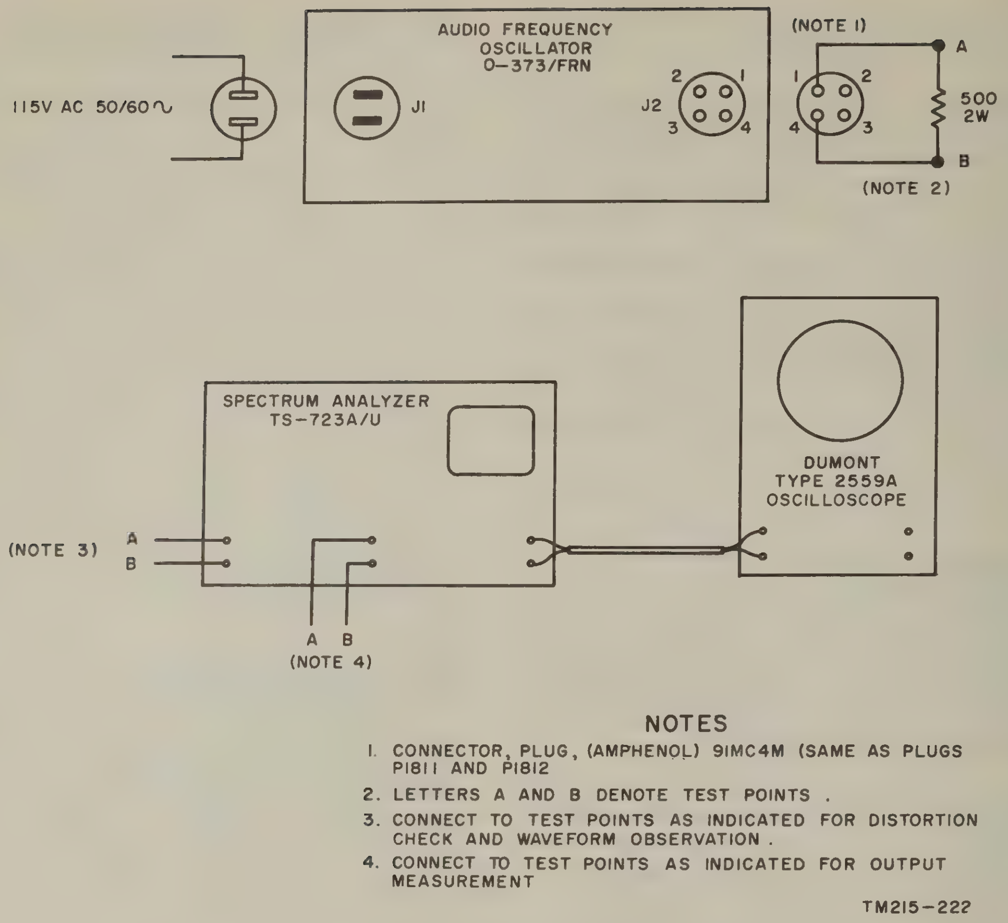
AUDIO FREQUENCY OSCILLATOR O-373/FRN
115V AC 50/60∿
J1
J2
1
2
3
4
(NOTE 1)
A
500 2W
B
(NOTE 2)
SPECTRUM ANALYZER TS-723A/U
DUMONT TYPE 2559A OSCILLOSCOPE
(NOTE 3)
A
B
A B
(NOTE 4)
NOTES
1. CONNECTOR, PLUG, (AMPHENOL) 91MC4M (SAME AS PLUGS P1811 AND P1812
2. LETTERS A AND B DENOTE TEST POINTS .
3. CONNECT TO TEST POINTS AS INDICATED FOR DISTORTION CHECK AND WAVEFORM OBSERVATION .
4. CONNECT TO TEST POINTS AS INDICATED FOR OUTPUT MEASUREMENT
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Figure 177. Audio Frequency Oscillator O-373/FRN, bench test setup.

c. Make the following connections for bench testing:

(1) Fabricate a power cable, use a male plug for connection to the test bench power source and a female plug (same as P814/P816, fig. 16) for connection to the O-373/FRN.

(2) Using male plug, American Phenolic Co. part No. 91-MC4M (same as P811/P812), make up the test plug by connecting the 500-ohm 2-watt output load resistor between terminals 1 and 4.

d. The spectrum analyzer is used for measuring output voltage, frequency, and distortion. It is used in conjunction with the oscilloscope to observe the output waveform, as described in TM 11-5097 for the spectrum analyzer.

301. Localizing Troubles

a. General. As a preliminary step, all tubes should be tested.

b. Preliminary Operational Check. Make a preliminary operational check of the component before performing the troubleshooting procedures. With the bench test connections made according to figure 177, apply power to the O-373/FRN. Be alert for signs of overload such as fuses blowing, smoke, burning sounds or smells. *Shut off the power* immediately if there are such signs.

c. Use of Chart. The procedures in the following troubleshooting chart will localize trouble to a faulty stage. Tracing faulty operation of that stage to a defective part within that stage is covered in paragraphs 304 and 305.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	No output from T1	No B+ from power supply or low B+ from power supply.	Check fuse and tubes (fig. 216). Check reactor L2 (par. 304*b*). Check reactor L3 (par. 304*b*). Check capacitor C8 for leakage (fig. 215). Check capacitor C9 for leakage. Check transformer T2 (par. 304*b*)
		Faulty output amplifier stage V2B.	Check output amplifier V2B voltage and resistance (fig. 178).
		Faulty audio amplifier stage V2A.	Check audio amplifier V2A voltage and resistance (fig. 178).
		Faulty oscillator stage, V1	Check oscillator stage voltage and resistance (fig. 178).
2	Low output from T1	Low B+ from power supply	Check transformer T2 (par. 304*b*). Check capacitor C8 for leakage. Check capacitor C9 for leakage.
		Faulty output amplifier stage V2B.	Check output amplifier V2B voltage and resistance (fig. 178).
		Faulty audio amplifier stage V2A.	Check audio amplifier V2A voltage and resistance (fig. 178).
		Faulty oscillator stage, V1	Check oscillator stage V1 voltage and resistance (fig. 178).
3	Output frequency unstable	Faulty oscillator V1 circuit	Check oscillator V1 circuit voltage and resistances (fig. 178).
		Incorrect B+ from power supply.	Check reactor L2 (par. 304*b*). Check reactor L3 (par. 304*b*). Check capacitor C8 for capacity. Check capacitor C3 for capacity. Check transformer T2 (par. 304*b*).
4	Distortion of output waveform.	Faulty output amplifier stage V2B.	Check output amplifier V2B stage voltage and resistance (fig. 178).
		Faulty audio amplifier stage V2A.	Check audio amplifier stage voltage and resistance (fig. 178).
		Faulty oscillator stage V1	Check oscillator stage V1 voltage and resistance (fig. 178).

302. Signal Tracing

a. Charted troubleshooting procedures can be augmented by signal tracing, using the vtvm setting of the spectrum analyzer. Connect the O–373/FRN to power and load, as shown in figure 177 and use the vtvm section of the spectrum analyzer at the points listed below.

b. The following table shows normal signal voltages at the important points of measurement in signal circuits.

Measurement points	Volts ac
Grid of V2A (pin 1) to chassis (fig. 215①)	18
Plate of V2A (pin 2) to chassis	6
Grid of V2B (pin 4) to chassis	[a] 6
Plate of V2B (pin 5) to chassis	[a] 54
Between terminals 3 and 5 of T1	[a] 9. 2

---

[a] With R15 set for maximum gain.

303. Stage Gain Checks

Use the following procedures to locate a defective stage when the output is low.

a. Remove tube V1 from its socket and turn gain control R15 to the full clockwise position.

b. Stage gains for the indicated input signal and the necessary test points are shown in the following chart. Apply the indicated input signal at a 1,000 cps, measure the output signal, and calculate the stage gain.

Step	Input connections	Input (v ac)	Test points	Stage gain
1	Pin 4 of V2 and chassis.	6	Pins 1 and 4 of J2	1. 53
2	Pin 1 of V2 and chassis.	18	Pins 1 and 4 of J2	. 51

304. Isolating Trouble

a. Voltage and resistance diagrams are given in figure 178, contained in separate envelope, which also includes notes on measurement procedures. These measurements will narrow the search for a defective part within a stage where trouble has been localized by procedures in the troubleshooting chart. Once a faulty portion of the circuit is located by voltage and resistance measurement, each part in that circuit portion is checked individually, following the schematic diagram (fig. 283).

b. Transformer and reactor winding dc resistances are given in the following chart. Component parts must be completely isolated before making resistance measurements.

Transformer or inductor	Connection points	Resistance (ohms)
L1	Across leads	125
L2	Across leads	420
L3	Across leads	420
T1	1–2	2, 500
	3–5	64
T2	BLK-BLK	11
	RED-RED	440
	YEL-YEL	3
	GRN-GRN	3

305. Additional Troubleshooting Data

a. Occasionally a tube which tests satisfactory may still be responsible for faulty operation. When this condition is suspected, substitution of tubes may clear up the trouble.

(1) If there is reason to suspect a particular tube, a direct substitution should be made.

(2) If no indication point to a particular tube, a complete set of new tubes may be substituted. If this clears up the trouble, replacement of the old tubes, one at a time, will eliminate the faulty tube.

(3) When substituting tubes, be sure to replace all original tubes which do not affect performance.

b. A part which tests normal may be responsible for faulty operation. When this condition is suspected, follow the part substitution procedure.

(1) Disconnect the suspected part from the circuit and temporarily substitute a replacement of the same value.

(2) If the replacement part restores correct operation, make the replacement permanent. If not, remove the substituted part and restore the original part to the circuit.

(3) When substituting parts, always use a replacement part of the same electrical value, tolerance, and rating as the original, and as near the same physical size as possible.

c. Before restoring the O–373/FRN to service after troubleshooting, make a quick voltage and resistance check and an operational test (par. 301).

Section X. COURSE MONITOR MX–1837/FRN–20 TROUBLESHOOTING

306. General

Monitor troubleshooting is accomplished with the component in its normal operating position or on the test bench. If previous tests show equipments No. 1 and No. 2 to be operating properly, the omnirange facility may be placed in operation to provide navigational information. The monitor will be isolated in either troubleshooting procedure and therefore will not provide the normal malfunction protection. Troubleshooting the monitor is sectionalized as follows: reference channel, variable channel, level channel, power supply, phase comparator, and alarm circuits. A thorough understanding of the theory of operation (section XIV, chapter 2) is necessary before troubleshooting the monitor.

***Warning:* High voltages are present in the monitor. Take adequate precautions against electrical shock at all times.**

307. Troubleshooting Reference Data

The following list of illustrations will be useful during troubleshooting of the monitor.

Fig. No.	Caption
16	Radio transmitting Set AN/FRN-22A, cording diagram.
24	Course Monitor MX-1837/FRN-20, tube locations.
32	Course Monitor MX-1837/FRN-20, fuse, control, and indicator locations.
48	Course Monitor MX-1837/FRN-20, interior view, control locations.
126	Integrated alarm circuit, schematic diagram.
285	Course Monitor MX-1837/FRN-20, schematic diagram.
159	Monitoring and alarm circuits, schematic diagram.
179	Course Monitor MX-1837/FRN-20, bench test setup.
180	Course Monitor MX-1837/FRN-20, voltage and resistance diagram.
181	Course Monitor MX-1837/FRN-20, waveforms.
217	Course Monitor MX-1837/FRN-20, front view.
218	Course Monitor MX-1837/FRN-20, front panel swung open, rear view.
219	Course Monitor MX-1837/FRN-20, rear view.
220	Course Monitor MX-1837/FRN-20, interior view.
221	Relay adjustment data.
297	Course Monitor MX-1837/FRN-20, wiring diagram.

308. Equipment Required for Troubleshooting.

a. Test Equipment. The test equipment required for troubleshooting the monitor is listed below with the applicable technical manual and common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME-77/U	TM 11-6625-203-12.	Multimeter.
Modulator MD-83A/ARN.	---------------	vor modulator.
Voltmeter ME-30A/U	TM 11-5132	AF vtvm.
Electronic Multimeter TS-505/U.	TM 11-5511	vtvm.
Electron Tube Test Set TV-2/U or	TM 11-2661	TV-2/U.
Electron Tube Test Set TV-7/U.	TM 11-5083	TV-7/U.
Oscilloscope, DuMont, type 2559A.	---------------	Oscilloscope.

b. Additional Equipment. The additional equipment required to troubleshoot the monitor is listed below with its common name.

Qty	Description	Common name
3	Safety door switch (cap portion) Bryant Electric Co. No. 4600A (Federal stock No. 5930-757-4130).	Interlock jumper plug.
2	Cord CG-530/U	Test cord.
1	Adapter UG-201/U	Adapter.
1	AF test cable (par. 366*b*)	Test cable.

309. Removal and Reinstallation

Removal and reinstallation involves no special procedures because the monitor is a self-contained unit. If the monitor is to be serviced in the CY-1897/FRN-22, it will be necessary to install interlock jumper plugs in interlock switches S801 and S802 (fig. 255), and to remove plug P802 from J2 and plug P9 from J1 (fig. 219) on the monitor. When bench servicing, remove cable W8 and use it as the 115-volt ac power cord to the monitor.

310. General Precautions

a. Controls. Do not change the settings of any of the controls and adjustments during troubleshooting unless specifically instructed to do so. Changing the settings will increase the difficulty in locating defective component parts. During troubleshooting, do not correct minor discrepancies with controls; the necessary adjustments are made in the alinement section of chapter 5 after repairs are made.

b. Short and B+ Test. Listed in the chart below are points to be checked with the multimeter for resistance values which will indicate shorts or leakages that could damage the monitor. These values may also show the source of the trouble and locate the defective part directly. All resistance measurements are taken between the test point and chassis.

Test point	Resistance (ohms)	Part checked
Tube V21, pins 5 or 6 (fig. 220 ④)	Infinite	C60, C61, C62, and C64.
Tube V19, pin 1	274K	C63.
Tube V19, pin 7	370K	C66.

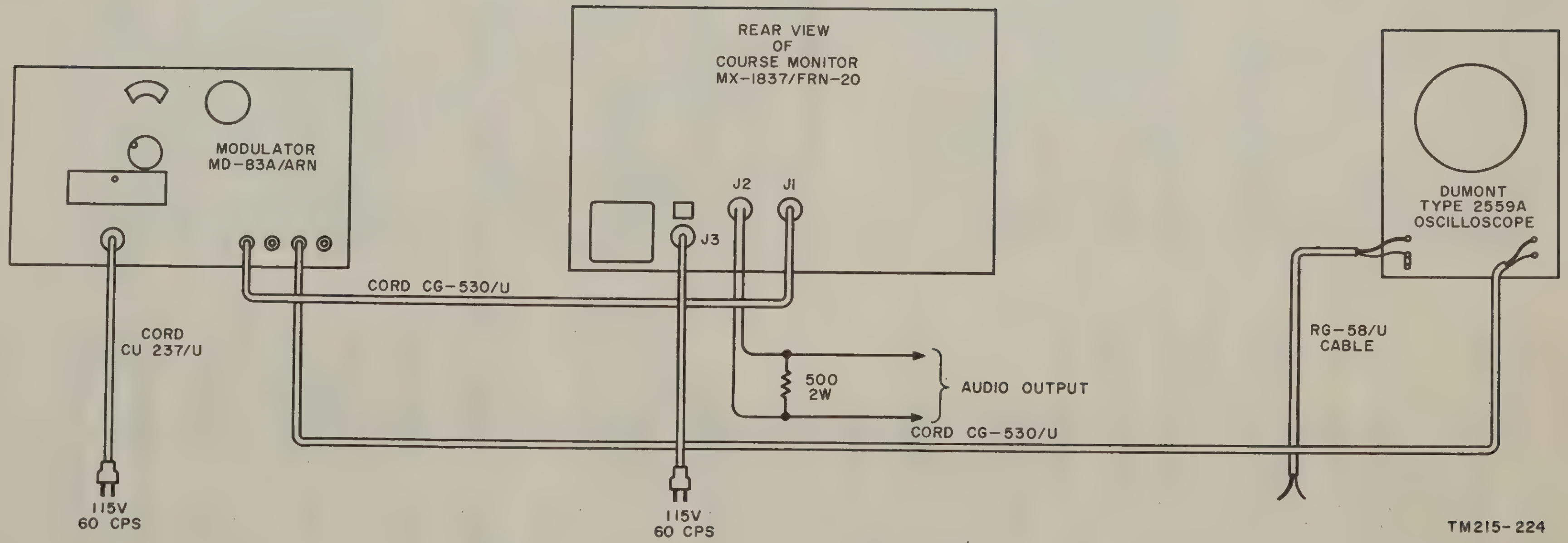


Figure 179. Course Monitor MX-1837/FRN-20, bench test setup.

311. Bench Test Setup

a. General. The bench test setup, shown in figure 179, includes the equipment listed in paragraph 308. All equipments and the monitor are to be operated from a reliable source of 115 volts, 60 cps, and the cables supplying the power must be kept as far away as possible from the test cables used for signal injection and measurement. Any stray 60-cycle pickup in the test will cause very erratic readings and false trouble indications. Be sure that the VOR modulator is accurately calibrated.

b. AF Test Prod Fabrication. The AF test prod is required for universal use during troubleshooting. Fabrication from bulk and spare stock is as follows:

(1) Cut a 10-inch length of RG–58/U coaxial cable and fasten a UG–89/U coaxial connector to one end.

(2) Carefully remove 4 inches of outer jacket from the other end of the coaxial cable. (Do not damage the shield braid.)

(3) Grasp the coaxial cable around the portion with the jacket and carefully push the shield braid toward the jacket to expand the shield.

(4) Bend the coaxial cable sharply at the jacket point, and with an awl, carefully spread the shield braid on the heel of the bend to make a hole in the shield braid. (Do not break any strands of the shield braid or damage the inner conductor insulation.)

(5) Carefully work the inner insulated conductor out through the hole in the shield braid. Straighten out the inner conductor and shield braid.

(6) Solder an insulated alligator clip to the end of the braid pigtail and fashion a small hook in the inner conductor end.

c. Test Connections with Monitor on Test Bench. Connect all test equipment as shown in figure 179. The output of the VOR modulator should be connected to receptacle J1 during all tests. Use Cord CG–530/U and Adapter UG–201/U for this connection. Supply ac power to the monitor through cable W8 (fig. 16).

d. Test Connections with Monitor in Cabinet. When the monitor is to remain in the CY–1897/FRN–22 for troubleshooting, remove plugs P802 and P9 (fig. 16) only, and make test equipment connections the same as the bench test setup (*c* above). Ac power input is obtained through the normal omnirange set source (cable W8). Insert interlock jumper plugs in interlocks S801 and S802 (fig. 225) and leave the door open.

312. Localizing Troubles

a. General. The major factor in troubleshooting the monitor is to sectionalize the trouble by channel as quickly as possible. The operational check shown in *b* below will sectionalize the trouble quickly. The breakdown of sections in the monitor is as follows: audio, power supply, vacuum-tube voltmeter, reference channel, variable channel, phase comparator, and alarm circuits.

b. Preliminary Operational Check. After completing a thorough visual inspection, energize the monitor and VOR modulator. Connect one end of test Cord CG–530/U to the MOD OUTPUT receptacle on the VOR modulator and the other end to receptacle J1 (fig. 219) on the monitor chassis with a UG–201/U adapter. Set the VOR modulator FUNCTION SELECTOR to SPECIFIC SIG position, the SPECIFIC SIGNAL SELECTOR to 9960FM/30 cps VAR, and adjust the MASTER ATTENUATOR to produce a 0.2-volt ac reading at the front right-hand terminal of INPUT LEVEL control R1. Use the multimeter or the af vtvm for this reading.

c. Operational Check Chart. Perform the steps given in the chart below to determine the channel or circuit which has the fault.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Set monitor LEVEL switch to INPUT position and check for audio output at pins 3 and 4 of J2 (fig. 219).	LEVEL METER indicates 100%, audio output is 3.5 volts ac.	LEVEL METER indicates low, audio is normal.	Troubleshoot level section of monitor (*d*(4) below).
			LEVEL METER indicates zero and audio output is zero.	Troubleshoot power supply (*d*(3) below).
			LEVEL METER indicates 100%, audio output is low or zero.	Troubleshoot audio circuit (*d*(7) below).
2	COURSE alarm lighted. Use vtvm on ac scale and check indications.	Measure 58 volts ac between pin 1 or 5 of V12 and chassis (fig. 220).	Low or no voltage	Troubleshoot reference channel (*d*(1) below).
		Measure 37 volts ac between pin 1 or 5 of V11 and chassis.	Low or no voltage	Troubleshoot variable channel (*d*(2) below).
			COURSE lamp lighted and normal voltage at pin 1 or 5 of V11 and V12.	Troubleshoot course alarm circuit (*d*(6) below). Troubleshoot phase comparator circuit (*d*(5) below).
3	REFERENCE alarm lighted; use vtvm on ac scale and check indications (COURSE alarm also lighted).	Measure 15 volts ac between pin 6 of V1 and chassis (fig. 220).	Low or no voltage	Troubleshoot reference channel (*d*(1) below).
			REFERENCE lamp lighted and normal voltage at pin 6 of V1.	Troubleshoot reference level alarm circuit (V6B, V17).
4	VARIABLE alarm lighted; use vtvm on ac scale and check indications (COURSE alarm also lighted).	Measure 1.7 volts ac between pin 2 of V3 and chassis.	Low or no voltage	Troubleshoot variable channel (*d*(2) below).
			VARIABLE lamp lighted and normal voltage at pin 2 of V3.	Troubleshoot variable channel (V7A, V16).

d. Use of Troubleshooting Chart. The following chart is broken down into channels and circuits, and is to be used in conjunction with the operational check in *c* above and organizational personnel reports. When the defective channel or circuit is found, locate the portion of the chart covering that channel or circuit and check the Indication column for the trouble. *Probable trouble* and *Procedure* columns will indicate the method required to isolate the trouble.

(1) *Reference channel chart.*

Item	Indication	Probable trouble	Procedure
1	REFERENCE and COURSE ALARMS lighted, LEVEL METER indicates low or zero level.	First and second amplifier stages (V2B, V1B) defective.	Measure signal voltages of V1B and V2B (par. 313*b*). Check waveform of V1B and V2B (fig. 181). Make voltage and resistance check, V1B and V2B (fig. 180).
		REF LEVEL control R5 improperly adjusted.	Recalibrate monitor (par. 48).
		Tuned circuit L1/C2 detuned-----	Realine L1/C2 (chapter 5). Troubleshoot alarm circuit (V6B, V17).
2	Same as item 1 but LEVEL METER indicates 100%.	Second amplifier stage V1B defective.	Make voltage and resistance checks on V1B (fig. 180).
3	COURSE alarm lighted, REFERENCE alarm and LEVEL METER normal.	Limiter V1A, slope detector V8B, third amplifier V4B, or output amplifier V12 defective.	Signal trace with waveforms (par. 313*c*). Make voltage and resistance check (fig. 180). Replace V1.
		Slope detector stage V8B defective.	Make voltage and resistance check (fig. 180). Replace V8. Aline tuned circuit C10/L2 (chapter 5). Check or substitute capacitors C11, C12, and C13 (fig. 220).
		Third amplifier stage V4B defective.	Make voltage and resistance check (fig. 180).
		Output amplifier stage V12 defective.	Make voltage and resistance check (fig. 180). Measure dc resistance of transformer T1 (par. 314*b*). Check or substitute capacitor C16 and C17.
		Phase comparator or alarm circuit defective.	Troubleshoot phase comparator (CR1, CR2, T2) and/or alarm circuit (V6B, V17).

(2) *Variable channel chart.*

Item	Indication	Probable trouble	Procedure
1	VARIABLE and COURSE ALARMS lighted, LEVEL METER indicates low or zero level.	Input amplifier stage V2A defective.	Measure signal voltages (par. 313*b*). Make voltage and resistance check (fig. 180). Check V2A waveform (fig. 181). Check or substitute capacitors C27 and C29 (fig. 220, 219).
		Switch S5 defective	Replace switch S5 (fig. 220).
2	Same as item 1 but LEVEL METER indicates 100%.	Capacitor C27 or C29 defective	Check or substitute capacitor.
		VAR LEVEL control R47 and/or VAR CAL control R48 misadjusted.	Recalibrate monitor (par. 48).
3	COURSE alarm lighted, VARIABLE alarm and LEVEL METER normal.	Inverter V4A, phase shift network (S4, R72), controlled amplifier V5, output amplifier V11, agc amplifier V3B or agc detector V6A stages defective.	Signal trace with waveforms (par. 313*c*). Measure signal voltages (par. 313*b*).
		Inverter stage V4A defective	Make voltage and resistance check (fig. 180).
		Phase shift network defective	Check network (par. 314*c*).
		Controlled amplifier stage V5 defective.	Make voltage and resistance check (fig. 180). Check or substitute capacitor C41 (fig. 218).
		Output amplifier stage V11 defective.	Make voltage and resistance check (fig. 180). Check or substitute capacitor C43 and C44 (fig. 218). Measure dc resistance of transformer T2 (par. 314*b*).
		Agc amplifier stage V3B defective.	Make voltage and resistance check (fig. 180).
		Agc detector stage V6A defective	Make voltage and resistance check. Check or substitute capacitor C38 and C40 (fig. 220). Replace V6.
		Phase comparator or alarm circuit defective.	Troubleshoot phase comparator or alarm circuit (charts (5) and (6)).

(3) *Power supply chart.*

Item	Indication	Probable trouble	Procedure
1	No B+ from power supply	No power input	Check fuse F1 and switch S3 (fig. 217).
		Defective rectifier V10 or transformer T4 (fig. 218).	Check V10. Check resistance of transformer T4 (par. 314*b*).
		Defective reactor L3 (fig. 219)	Check L3 resistance (par. 314*b*).
		Open resistor R116 (fig. 220)	Check R116 resistance.
		Defective voltage regulators V19, V20, V21, and V22 (fig. 219).	Make voltage and resistance check (fig. 193).
			Check or substitute capacitors C62, C63, and C64 (fig. 219, 220).
2	Low or high B+ from power supply.	Defective voltage regulators V19, V20, V21, and V22.	Check tubes. Make voltage and resistance check (fig. 180). Check or substitute capacitors C60, C61, C62, C63, C64, and C65 (fig. 219, 220). Check relay RY5 coil resistance (fig. 220).
3	Bias voltage output incorrect	Resistor R116 open (fig. 220)	Replace resistor.
		Capacitor C65 shorted (fig. 219)	Replace capacitor.
		Relay RY5 coil defective (fig. 219)	Check coil resistance (fig. 221).
		B+ load from monitor circuits incorrect.	Make voltage and resistance checks all tubes (fig. 180).
4	Excessive ripple on B+	Defective capacitors	Check or substitute capacitors C60, C61, C62, C63, C64, and C65.
		Reactor L3 defective (fig. 219)	Check resistance (par. 314*b*) or substitute.

(4) *Level circuit chart.*

Item	Indication	Probable trouble	Procedure
1	No LEVEL METER readings, input to switch S1 normal.	Defective LEVEL METER M3	Replace meter.
		Defective stage in level circuit (V13 and V14).	Signal trace by signal voltage measurements (par. 313*b*). Make voltage and resistance checks (fig. 180).
		Capacitor C57 shorted or leaky	Check or substitute capacitor C57 (fig. 220).
2	Low LEVEL METER readings, all positions of LEVEL switch S1.	Defective V13 or V14 (fig. 219)	Check or substitute tubes. Recalibrate monitor (par. 48).
3	LEVEL METER readings erratic	Capacitor C57 defective (fig. 220)	Replace capacitor C57.
		LEVEL METER defective (fig. 217).	Replace meter M3.

(5) *Phase comparator chart.*

Item	Indication	Probable trouble	Procedure
1	COURSE alarm on all the time, unable to obtain balanced meter indications with control R37 (fig. 220).	Rectifiers CR1 and CR2 (fig. 217) defective.	Replace rectifiers CR1 and CR2 (ch. 5).
		Defective transformer T1 or T2 (fig. 219).	Check resistance (par. 314*b*) or substitute transformers T1 or T2 (par. 315*b*).
		Defective capacitors C1, C24, or C25 (fig. 218, 219, 220).	Check or substitute capacitors C1, C24, and C25.
		Alarm circuit defective	Troubleshoot alarm circuit (chart (6)).
		Reference or variable channels defective.	Troubleshoot reference and variable circuits (charts (1) and (2)).
		Monitor not properly calibrated	Recalibrate monitor (par. 48).
2	Deflection sensitivity of meters M1 and M2 incorrect.	Rectifiers CR1 and CR2 defective	Replace rectifiers CR1 and CR2 (ch. 7).
		Relay RY1 (fig. 220) contacts closed.	Check relay and adjustment (fig. 221).
		Capacitor C24 or C25 leaky	Check or substitute capacitors C24 or C25.
		Sensitivity control R39 incorrectly set.	Recalibrate monitor (par. 48).

(6) *Alarm circuits chart.*

Item	Indication	Probable trouble	Procedure
1	COURSE RELAY meter M2 does not indicate zero (no power to monitor).	COURSE RELAY meter M2 needle not mechanically zeroed or defective.	Reset the meter needle mechanically to zero (fig. 217). ***Caution:* Follow the procedure given in paragraph 48.** Replace the meter.
2	COURSE alarm lighted, REFERENCE and VARIABLE ALARMS normal, and meters M1 and M2 indicate normal courses.	Same as item 1 above	Same as item 1 above.
		Defective contacts on relay RY4 (fig. 220).	Check relay adjustment (fig. 221). Check relay coil resistance (fig. 221).
		Defective reference fail-safe alarm detector V8A or thyratron V18 stages (fig. 219).	Check or substitute tubes (par. 315*a*). Make voltage and resistance check of V8A and V18 (fig. 180). Check or substitute capacitors C21, C22, or C23 (figs. 219, 220).
		No 115 volts ac plate supply to V18.	Check contact adjustments of relays RY1, RY2, RY3, and RY5 (figs. 220, 221). Troubleshoot all level, fail-safe and bias relay circuits for faults which could cause a relay to interrupt the 115 volt ac supply (fig. 126), and check VARIABLE and REFERENCE lamps.
		Defective variable fail-safe alarm detector V7B and thyratron V15 stages.	Check or substitute tubes (fig. 219). Make voltage and resistance check of V7B and V15 (fig. 180). Check or substitute capacitors C45, C46, and C26 (fig. 220).
3	REFERENCE and COURSE ALARMS lighted, meters M1 and M2 indicate normal courses.	Defective reference level alarm detector V6B or thyratron V17 stages.	Check or substitute tubes. Make voltage and resistance check of B6B and V17 (fig. 180). Check or substitute capacitors C18, C19, and C20 (fig. 220).
		Relay RY3 defective (fig. 220)	Check relay adjustment (fig. 221).

Item	Indication	Probable trouble	Procedure
3	REFERENCE and COURSE ALARMS lighted, etc.—Con.	REF ALARM control R19 (fig. 220) incorrectly adjusted.	Recalibrate monitor (par. 48).
4	VARIABLE and COURSE ALARMS lighted, meters M1 and M2 indicate normal courses.	Defective variable level alarm amplifier V3A, detector V7A, or thyratron V16 stages.	Check or substitute tubes. Make voltage and resistance check of V3A, V7A, and V16 (fig. 180). Check or substitute capacitors C48 and C49 (fig. 220).
		Relay RY2 (fig. 220) defective	Check relay adjustment (fig. 221).
		VAR ALARM control R91 (fig. 220) incorrectly adjusted.	Recalibrate monitor (par. 48).

(7) *Audio circuit chart.*

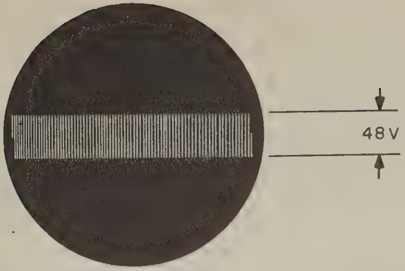
Item	Indication	Probable trouble	Procedure
1	Low or no audio output at pins 3 and 4 of receptacle J2 (fig. 219).	Defective first audio or output amplifiers V9.	Check or substitute tubes. Make voltage and resistance check of V9 (fig. 180). Check or substitute capacitor C50 (fig. 220). Check transformer T3 (fig. 219) resistance (par. 314*b*).
2	Distorted audio output at pins 3 and 4 of receptacle J2.	Defective capacitor C50, C51, C52, or C53 (fig. 220).	Check or substitute capacitors.
		Transformer T3 defective	Replace transformer T3.

313. Signal Tracing

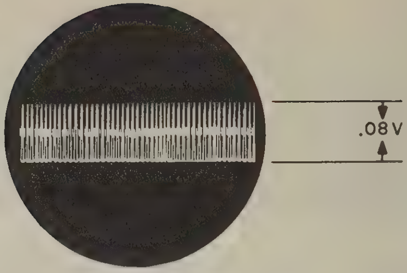
a. General. Two methods are contained in this paragraph to aid in localizing trouble; signal tracing by signal voltage and signal tracing by waveforms. Either method may be used, but the waveform method has the advantage of a visual indication of the actual signal. The signal voltage method is more easily accomplished and requires less time.

b. Signal-voltage Tracing. All signal voltage values in figure 180 are to be measured with the multimeter set up for ac operation in accordance with instructions in TM 11-5511. All voltages are rms values measured between the test point and chassis. When signal tracing, start at the point where a signal is known to be normal and proceed toward the phase comparator or alarm lamp circuits. The point at which a low or no signal voltage is present indicates the defective stage. Connect the monitor and the VOR modulator (fig. 179) and allow at least 10 minutes for the equipment to stabilize after power is applied. Set the VOR modulator operation and output as specified in paragraph 312*b*. All equipment controls and adjustments are to remain at their normal operating settings. Do not adjust controls to compensate for incorrect voltages; locate the cause of the faulty voltage, and then repair and make calibration adjustments of the complete monitor as instructed in paragraph 48.

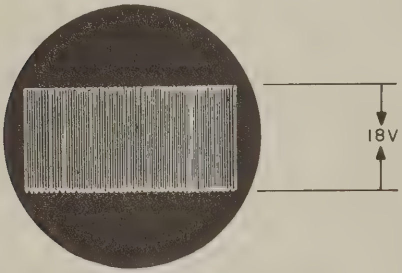
c. Waveform Signal Tracing. The waveforms (fig. 181) are provided for the points in the monitor where circuit component operation changes the shape of the signal. By reference to the schematic diagram (fig. 285) and the waveforms of figure 181, the wave shape may be checked at any point along the signal paths of the monitor. Voltage amplitudes (fig. 181) are peak-to-peak values and the oscilloscope instruction manual should be consulted for details of oscilloscope calibration. The monitor and VOR modulator should be connected as shown in figure 179 and the output adjusted in accordance with procedure given in paragraph 312*b*. Figure 181 indicates the oscilloscope horizontal sweep frequency to be used for each waveform. The settings of the oscilloscope are not critical unless voltage amplitudes and the number of complete cycles to be observed are of importance. The wave shape is the most important. All waveforms are to be measured between the test point and chassis with the test cable (par. 311*b*). Any deviation from the wave shapes shown in figure 181 should be further investigated by isolating procedures in the stage which first shows the change.



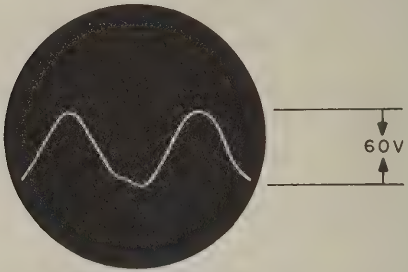
LIMITER
V1A PIN 1
SIGNAL FREQUENCY: 9,960 CPS FM
SWEEP FREQUENCY: 330 CPS



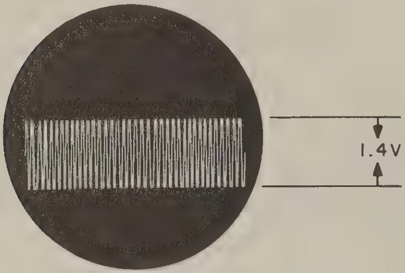
1ST AMPLIFIER
V2B PIN 7
SIGNAL FREQUENCY: 9,960 CPS FM
SWEEP FREQUENCY: 330 CPS



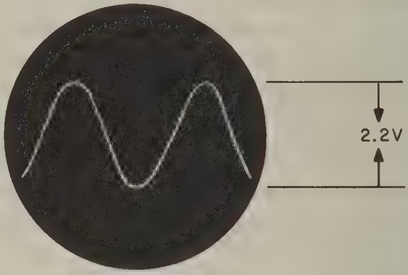
LIMITER
V1A PIN 2
SIGNAL FREQUENCY: 9,960 CPS FM
SWEEP FREQUENCY: 330 CPS



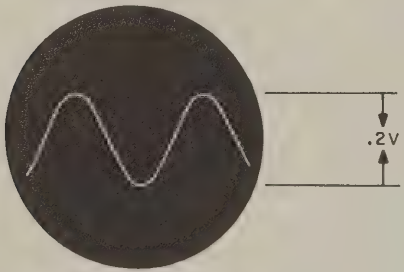
AGC AMPLIFIER
V3B PIN 6
SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 15 CPS



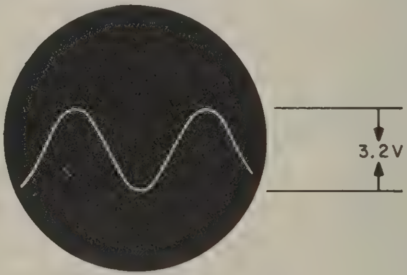
2D AMPLIFIER
V1B PIN 7
SIGNAL FREQUENCY: 9,960 CPS FM
SWEEP FREQUENCY: 330 CPS



INVERTER
V4A PIN 1
SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 15 CPS



INPUT AMPLIFIER
V2A PIN 2
SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 15 CPS



INVERTER
V4A PIN 2
SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 15 CPS

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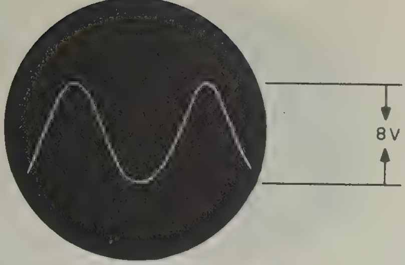
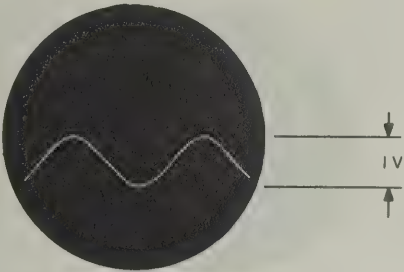
Figure 181. Course Monitor MX-1837/FRN-20, waveforms.



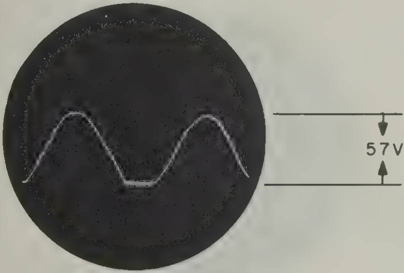
3D AMPLIFIER
V4B PIN 7

SIGNAL FREQUENCY 30 CPS REF
SWEEP FREQUENCY 15 CPS



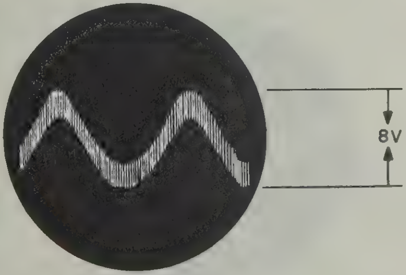
CONTROLLED AMPLIFIER
V5 PIN 1

SIGNAL FREQUENCY 30 CPS VAR
SWEEP FREQUENCY 15 CPS



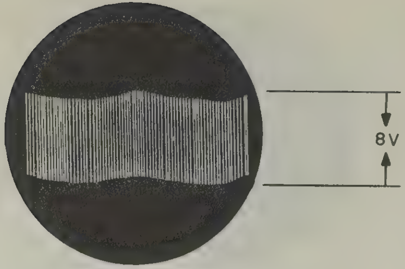
AGC DETECTOR
V6A PIN 5

SIGNAL FREQUENCY 30 CPS VAR
SWEEP FREQUENCY 15 CPS



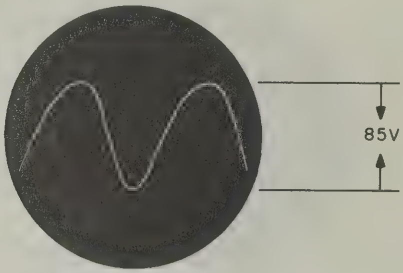
SLOPE DETECTOR
V8B PIN 1

SIGNAL FREQUENCY 30 CPS REF
SWEEP FREQUENCY 15 CPS



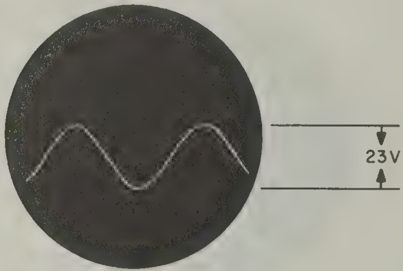
AUDIO OUTPUT AMPLIFIER
V9B PIN 6

SIGNAL FREQUENCY 9,960 CPS FM AND 30 CPS VAR
SWEEP FREQUENCY 15 CPS



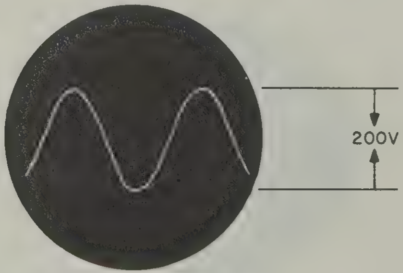
OUTPUT AMPLIFIER
V11 PIN 1,5

SIGNAL FREQUENCY 30 CPS VAR
SWEEP FREQUENCY 15 CPS



OUTPUT AMPLIFIER
V11 PIN 6

SIGNAL FREQUENCY 30 CPS VAR
SWEEP FREQUENCY 15 CPS



OUTPUT AMPLIFIER
V12 PIN 1,5

SIGNAL FREQUENCY 30 CPS REF
SWEEP FREQUENCY 15 CPS

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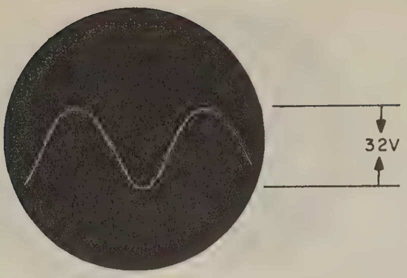
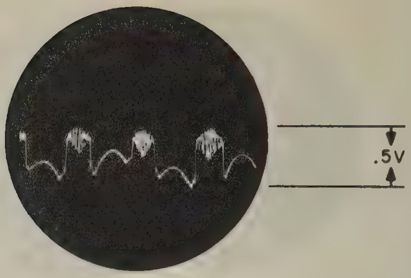
Figure 181—Continued



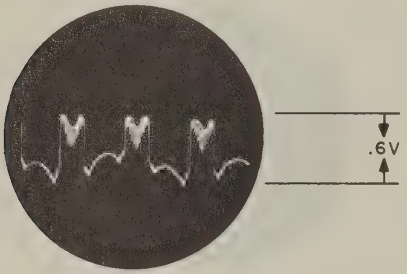
OUTPUT AMPLIFIER
V12 PIN 6

SIGNAL FREQUENCY: 30 CPS REF
SWEEP FREQUENCY: 15 CPS



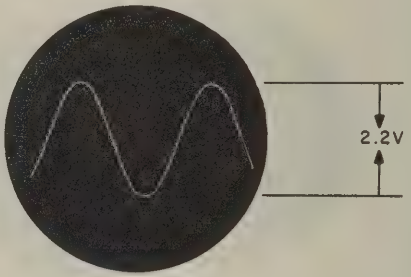
REFERENCE FAIL-SAFE ALARM THYRATRON
V18 PIN 1

SIGNAL FREQUENCY: 30 CPS REF
SWEEP FREQUENCY: 7.5 CPS



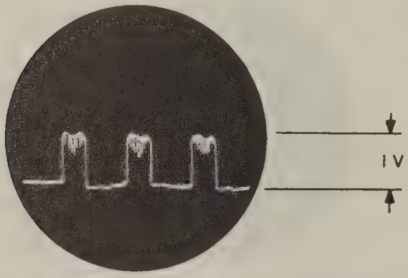
VARIABLE FAIL-SAFE ALARM THYRATRON
V15 PIN 1

SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 7.5 CPS



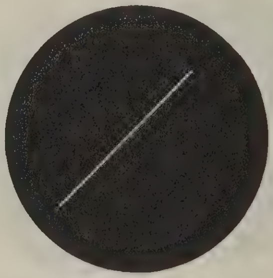
INVERTER
JUNCTION OF RESISTORS R50 AND R51, V4A

SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 15 CPS



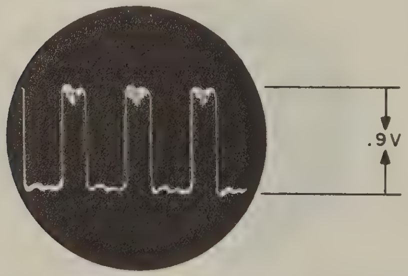
VARIABLE LEVEL ALARM THYRATRON
V16 PIN 1

SIGNAL FREQUENCY: 30 CPS VAR
SWEEP FREQUENCY: 7.5 CPS



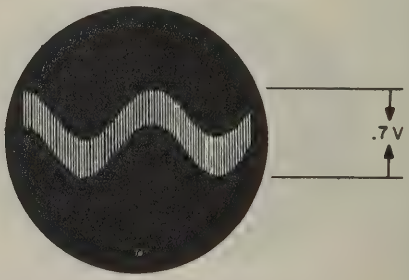
IN-PHASE LISSAJOUS PATTERN
(SEE TEXT)

Y-INPUT: 30 CPS
X-INPUT: 30 CPS REF



REFERENCE LEVEL ALARM THYRATRON
V17 PIN 1

SIGNAL FREQUENCY: 30 CPS REF
SWEEP FREQUENCY: 7.5 CPS



INPUT LEVEL CONTROL R1
RIGHT FRONT TERMINAL R1

SIGNAL FREQUENCY: 9,960 CPS FM AND 30 CPS
SWEEP FREQUENCY: 15 CPS

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Figure 181—Continued

314. Isolating Troubles

a. Voltage and Resistance Measurements. The voltage and resistance measurements (fig. 180, contained in separate envelope) are used to help isolate troubles to a specific part. Use the multimeter for the resistance measurements with all external connections to the monitor disconnected. Test equipment to be used for voltage measurements is specified in figure 180 and measured with zero signal input to the monitor.

b. Transformer and Reactor Dc Resistance Measurements. All measurements in the chart below are to be made with the multimeter. Disconnect the transformer or reactor from the circuit before measuring resistances. All power must be removed and external connections disconnected.

Transformer or reactor	Connections points	Resistance (ohms)
L1 (fig. 219)	Across leads	840
L2	Across leads	840
L3	Across leads	190
M2	(Reset winding only)	16, 500
T1 and T2	1–2	950
	3–4	56
	5–6	56
T3	1–2	200
	3–4	24
T4	0–115 (primary)	7
	Across 115V winding (secondary).	39
	6.3V winding	Less than 1
	6.3V winding	Less than 1
	6.3V winding	Less than 1
	0–400	128
	400–400	128

c. Phase Shift Network Test. Perform this test when it is impossible to zero the monitor to the AN/FRA–14 or a test signal when all other circuit components are normal. Perform the following steps in the order given:

(1) Connect the monitor and test equipment as shown in figure 179. Energize the equipment, allow time for it to stabilize, and adjust the input to the monitor as instructed in paragraph 312*b*.

(2) Refer to the oscilloscope instruction manual and adjust the oscilloscope for an external horizontal sweep which produces a suitable horizontal line.

(3) Connect the common oscilloscope Y INPUT terminal to the monitor chassis and the remaining terminal to the junction of C34 and C36 (fig. 220). Adjust the PHASE ANGLE SELECTOR of the VOR modulator to produce an in-phase Lissajous pattern (fig. 181).

(4) Record the phase angle read on the VOR modulator dial and move the Y INPUT oscilloscope lead to the junction of C33 and C35 (fig. 220). Adjust the PHASE ANGLE SELECTOR for an in-phase indication (fig. 181), and again record the phase angle.

(5) Move the Y INPUT oscilloscope lead to the junction of capacitor C35 and resistor R53, adjust the PHASE ANGLE SELECTOR for in-phase indication (fig. 181), and record the phase angle.

(6) Connect the oscilloscope Y INPUT to the junction of capacitor C36 and resistor R73 (fig. 220) adjust the PHASE ANGLE SELECTOR for in-phase indication (fig. 181), and record phase angle.

(7) The angular difference between test points C34/C36 and C33/C35 should be 180 ±2°. If not, capacitor C33 or C34 is defective and must be replaced. The angular difference between test points C35/R53 and C36/R73 should be 180 ±2° and either point should be 90 ±2° displaced from test points C34/C36 or C33/C35. If not, capacitor C35 or C36 is defective and must be replaced.

(8) A check of switch S4 and PHASE ZERO control R72 is made by connecting the oscilloscope Y INPUT between pin 7 of tube V3 (fig. 220) and chassis. Set the PHASE ANGLE SELECTOR to obtain an in-phase indication (fig. 181) for each position of switch S4. Each position should produce an 18 ±2° change. If not, one of the resistors R54 through R71 is defective. PHASE ZERO control R72 should produce 20 ±3° of change.

315. Additional Troubleshooting Information.

a. Tube Substitution. Unusual circuit characteristics may cause certain tubes to fail in the monitor but test normal in the tube tester. When circuit component parts check normal and trouble still exists, substitute a new tube or tubes in the defective stage. If the trouble is not corrected, do not leave the new tube in the socket.

b. Parts Substitution. The change in characteristics of component parts within the monitor may change in a manner which will be difficult for the technician to detect with available test equipment. Temporarily substitute a part known to be good and check the results. The original part must be isolated from the circuit in all cases. Do not leave the substitute part in place if the trouble is not corrected.

c. Repairs and Alinement. When trouble has been isolated, refer to chapter 5 for repair and alinement procedures.

Section XI. ELECTRICAL EQUIPMENT CABINET WIRING TROUBLESHOOTING

316. General

a. There are four electrical equipment cabinets at the omnirange site, each of which contains its own electrical circuits. A fifth, the remote control cabinet, completes the cabinet complement of the omnirange set, but is not discussed here because it contains no electrical wiring.

b. The cabinets covered in this section are:

(1) One Electrical Equipment Cabinet CY-1897/FRN-22.
(2) Two Electrical Equipment Cabinets CY-1899/FRN-22.
(3) One Electrical Equipment Cabinet CY-2274/FRN-22A.

c. Cabinet wiring in each case includes the cabinet heating and ventilating circuit, ac distribution circuit, and interunit wiring for the units within the same cabinet.

317. Access to Cabinet Interiors

a. To gain greater working space, remove the rear door of the cabinets when troubleshooting the cabinet wiring. Remove the door by removing the blower power plug from the power receptacle and lifting the door off its hinge pins.

b. To replace the door, raise it into position, with the hinge plates of the door above and in line with the hinge pins. Lower the door hinge plates onto the hinge pins and insert the blower power plug in the power receptacle.

c. In some cabinets, equipment components must be removed to give access to portions of the cabinet wiring, principally heaters, heater terminal boards, and thermostatic switches.

318. General Precautions

***Warning:* Dangerous voltages are present in all equipment cabinets when the equipment is in a standby condition, as well as when energized. Use caution when making measurements on energized circuits. Avoid physical contact with exposed parts and terminals.**

a. Five circuit breakers control the power to all cabinets. In addition, the main circuit breaker, K1001, controls all power to the ac distribution circuit. Specific details are discussed under the specific cabinet data.

b. Each cabinet contains from two to four interlock switches, for protection from dangerous voltages. In each case two interlock switches are provided for the 230-volt heating and ventilating circuit, with one interlock switch in each leg of the 230-volt line. Both interlock switches must be closed to energize the heating and ventilating circuit. Specific details on interlock switches are given for each cabinet, and will be dealt with later in discussion of the individual cabinets.

319. Equipment Required

a. Test Equipment. Test equipment required for cabinet wiring troubleshooting is listed below, with applicable technical manual and assigned common name.

Test equipment	Technical manual	Common name
Multimeter ME-77/U	TM 11-6625-203-12.	Multimeter.

***Caution:* The cabinet wiring includes ac distribution wiring as well as interunit connections; therefore, continuity measurements with the multimeter resistance scale should be made with care. Damage to the multimeter will result from making resistance measurements on an energized 115-volt or 230-volt line.**

b. Additional Equipment. Additional equipment required for troubleshooting is listed below.

Qty	Description	Common name
4	Safety door switch (cap portion) Bryant Electric Co. No. 4600A. (Federal stock No. 5930–757–4130.)	Interlock jumper plug.
1	8-inch wire lead with alligator clip on each end.	Test lead.
1	Tool Equipment TE–113	Tool kit.

320. General Troubleshooting Procedures

a. Troubleshooting procedures for cabinet wiring involves voltage measurements and short and continuity checks.

b. Check faulty thermostatic switches by jumpering the suspected thermostat with the test leads. If the blower or heater operates when its thermostat is jumpered, but does not operate at the proper temperature, replace the thermostat.

c. When checking shorts and continuity in cabinet wiring, follow these special precautions.

(1) When measurements at plugs or sockets are to be made, salvage pins or clips of the proper size from damaged plugs or receptacles. Solder a 2-inch piece of stiff bare wire to each pin or clip for connecting meter leads after inserting the pin or clip in the point under test.

(2) In continuity checking, make measurements for shorts to ground as well as from point to point. Do this with *no voltage applied.*

(3) Remove the plug of the circuit involved, when measuring continuity, to limit the check to cabinet wiring. This avoids checking open relays or switches in equipment units that show an open circuit where there should be continuity.

321. Troubleshooting Electrical Equipment Cabinet CY–1897/FRN–22

a. The CY–1897/FRN–22 contains the following equipment components listed in the proper order from the cabinet top.

(1) C–1840/FRN–22.
(2) Monitor.
(3) C–1738/FRN–20.
(4) RE–248/FRN–22.
(5) RE–247/FRN–22.
(6) O–373/FRN, equipment No. 1.
(7) Keyer, equipment No. 1.
(8) O–373/FRN, equipment No. 2.
(9) Keyer, equipment No. 2.
(10) PP–1415/FRN–22.
(11) Voltage regulator.

b. The following list of illustrations on chart will be helpful in troubleshooting the CY–1897/FRN–22 circuits.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
29	Typical electrical equipment cabinet, fuse location.
148	Ac power distribution circuit, schematic diagram.
149	Heating and ventilating circuits, schematic diagram.
150	Interlock and protective circuits, schematic diagram.
225	Electrical Equipment Cabinet CY–1897/FRN–22, interior view.
298	Electrical Equipment Cabinet CY–1897/FRN–22, wiring diagram.

c. Troubleshooting of the CY–1897/FRN–22 is not shown by charter troubleshooting procedure; it is carried out by referring to the wiring diagram (fig. 298) and guided by indications obtained when troubleshooting by starting procedure.

d. Circuit breakers affecting the CY–1897/FRN–22 circuits are given in the following table.

Circuit breaker	Controlled voltage and circuit
K1001	230 volts ac, to voltage regulator. K1001 is the main breaker.
K1003	115 volts ac, to the RE–247/FRN–22 (J804 and J805 in fig. 225).
K1004	115 volts ac, to all other units in CY–1897/FRN–22 (through J801, J803, and J807 (fig. 16); also J802, J806, and J808, which are unused).
K1015	230 volts ac, to cabinet blower and heaters.

e. Two interlock safety switches, S801 and S802 (fig. 225) are located in the CY–1897/FRN–22 at the top right corner of the rear door opening. Both control 230 volts ac to the cabinet blower and heaters, and must be closed before any part of the heating and ventilating circuit will operate.

f. As in all troubleshooting, a visual inspection of cabinet wiring should be made before applying power or initiating other troubleshooting procedures.

322. Troubleshooting Electrical Equipment Cabinets CY–1899/FRN–22

a. The omnirange set includes two CY–1899/FRN–22 cabinets, one for equipment No. 1 and the other for equipment No. 2. They are identical in content and internal wiring and differ only in their external termination points through intercabinet wiring. Each cabinet contains the following equipment components:

(1) Goniometer.
(2) Modulation eliminator.
(3) Transmitter.
(4) PP–1331/FRN–20.
(5) PP–1329/FRN–20.

b. The following list of illustrations on chart will be helpful in troubleshooting the wiring in the CY–1899/FRN–22.

Fig. No.	Caption
11	Electrical Equipment Cabinet CY–1899/FRN–22, component installation diagram.
29	Typical electrical equipment cabinet, fuse location.
226	Electrical Equipment Cabinet CY–1899/FRN–22, interlock switch locations.
148	Ac power distribution circuits, schematic diagram.
149	Heating and ventilating circuits, schematic diagram.
150	Interlock and protective circuits, schematic diagram.
226	Electrical Equipment Cabinet CY–1899/FRN–22, interior view.
299	Electrical Equipment Cabinet CY–1899/FRN–22, wiring diagram (equipment No. 1).
300	Electrical Equipment Cabinet CY–1899/FRN–22, wiring diagram (equipment No. 2).

c. Troubleshooting the CY–1899/FRN–22 is not shown by charted troubleshooting procedures; it is carried out by referring to the wiring diagram (fig. 299 or 300) and guided by indications obtained when troubleshooting by the starting procedure.

d. Circuit breakers affecting the CY–1899/FRN–22 are listed in the following table.

Circuit breaker	Controlled voltage and circuit
K1001	230 volts ac, to the entire omnirange site equipment (main circuit breaker).
K1003	115 volts ac, to the RE–247/FRN–22 in the CY–1897/FRN–22 (necessary to get 115 volts ac to PP–1331/FRN–20).
K1004	115 volts ac, to the other components in the CY–1897/FRN–22 (necessary to apply primary voltages to the other power supplies).
K1011	230 volts ac, to the PP–1329/FRN–20, equipment No. 1.
K1012	230 volts ac, to the PP–1329/FRN–20, equipment No. 2.
K1015	230 volts ac, to the heating and ventilating circuits.

e. Three interlock safety switches, S1801, S1802, and S1803, are located in each CY–1899/FRN–22 at the top right corner of the rear door opening (fig. 226). Switch S1801 controls power to the PP–1329/FRN–20. S1802 and S1803 control power to the blower and heaters, and both must be closed before any part of the heating and ventilating circuit will operate. A visual inspection should be made before applying power or initiating other troubleshooting procedures.

323. Troubleshooting Electrical Equipment Cabinet CY–2274/FRN–22A

a. The CY–2274/FRN–22A contains the following equipment components:

(1) Meter panel.
(2) O–371/FRN–20, equipment No. 1.
(3) AM–1246/FRN–20, equipment No. 1.
(4) O–371/FRN–20, equipment No. 2.
(5) AM–1246/FRN–20, equipment No. 2.

b. The following list of illustrations will be helpful in trouble shooting the CY-2274/FRN-22A wiring.

Fig. No.	Caption
12	Electrical Equipment Cabinet CY-2274/FRN-22A, component installation diagram.
29	Typical electrical equipment cabinet, fuse location.
148	Ac power distribution circuits, schematic diagram.
149	Heating and ventilating circuits, schematic diagram.
150	Interlock and protective circuits, schematic diagram.
227	Electrical Equipment Cabinet CY-2274/FRN-22A, interior view.
301	Electrical Equipment Cabinet CY-2274/FRN-22A, wiring diagram.

c. Troubleshooting the CY-2274/FRN-22A wiring is not shown by charted troubleshooting procedure; it is carried out by referring to the wiring diagram (fig. 301) and guided by indications obtained when troubleshooting by the starting procedure.

d. Circuit breakers affecting the CY-2274/FRN-22A circuits are listed in the following chart.

Circuit breaker	Controlled voltage and circuit
K1001	230 volts ac, to entire omnirange site equipment.
K1003	115 volts ac, to the RE-247/FRN-22.
K1004	115 volts ac, to the other CY-1897/FRN-22.
K1015	230 volts ac, to heating and ventilating circuit.
K1011	230 volts ac to O-371/FRN-20 and AM-1246/FRN-20 through the PP-1329/FRN-22 in the No. 1 CY-1899/FRN-22.
K1012	230 volts ac to O-371/FRN-20 and AM-1246/FRN-20 through the PP-1329/FRN-20 in the No. 2 CY-1899/FRN-22.

e. Four interlock safety switches, S1903, S1904, S1905, and S1906 are located in the CY-2274/FRN-22A at the top right corner of the rear door opening (fig. 227). Switch S1903 controls power to the high voltage supplies of equipment No. 1, and S 1904 controls power to high-voltage supplies of equipment No. 2. The S1905 and S1906 both control power to the cabinet blower and heaters, and must be closed before any part of the heating and ventilating circuit will operate. A visual inspection should be made before applying power or initiating other troubleshooting procedures.

Section XII. ELECTRICAL GONIOMETER GO-12/FRN-20 TROUBLESHOOTING

324. General

The goniometer troubleshooting described in this section is performed on a test bench, and is primarily concerned with the subcarrier generator circuits. Troubleshooting of the variable carrier portion of the goniometer is treated separately in section IV of this chapter because of the complexity of the antenna circuits. All troubleshooting procedures for the goniometer require extreme accuracy to locate a trouble properly.

325. Troubleshooting Reference Data

The following list of illustrations on chart will be useful when troubleshooting the goniometer.

Fig. No.	Caption
16	Radio Transmitting Set AN/FRN-22A, cording diagram.
17	Electrical Goniometer GO-12/FRN-20, tube and control locations.
30	Electrical Goniometer GO-12/FRN-20, fuse and control locations.
278	Electrical Goniometer GO-12/FRN-20, schematic diagram.
182	Electrical Goniometer GO-12/FRN-20, bench test setup.
183	Electrical Goniometer GO-12/FRN-20, voltage and resistance diagram.
228	Electrical Goniometer GO-12/FRN-20, top view.
229	Electrical Goniometer GO-12/FRN-20, bottom view.
230	Electrical Goniometer GO-12/FRN-20, subchassis interior view.
304	Electrical Goniometer GO-12/FRN-20, wiring diagram.

326. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting is listed below with the applicable technical manual and the assigned common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Spectrum Analyzer TS–723A/U.	TM 11–5097	Spectrum analyzer.
Oscilloscope, DuMont, Type 2559A.		Oscilloscope.
Frequency Meter AN/URM–32.	TM 11–5120	AN/URM–32.
Frequency Meter FR–67/U.	TM 11–2698	FR–67/U.
Voltmeter, Meter ME–30A/U.	TM 11–5132	af vtvm.
Electronic Multimeter TS–505/U.	TM 11–5511	vtvm.
Electron Tube Test Set TV–2/U or.	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment. The additional equipment required to troubleshoot the goniometer subchassis is listed below with its common name.

Qty	Description	Common name
1	1,000 ohm, ½ watt ±10% composition resistor.	Load resistor.
1	Power supply; 230 volts dc at 30 ma, 6.3 volts ac at 1.5 amp, ±5%.	Power supply.
1	Fabricated cable (par. 329*a*)	Power supply cable.

327. Removal and Reinstallation

a. Removal from Cabinet. Remove the goniometer from the CY–2274/FRN–22A in the following order:

(1) Disconnect the connectors from receptacles J1, J3, J4, J5, J6, and J7 (fig. 16).

(2) Remove the cabinet trim strips (fig. 11), support the chassis from the rear, and remove the panel screws. Carefully lift the chassis and withdraw it from the cabinet. Do not lift the chassis too high; the goniometer capacitor vernier indicator will get caught on the cabinet.

b. Removal of Subchassis. To gain access to the component parts of the subcarrier subchassis, refer to figure 17 and proceed as follows:

(1) Disconnect the ground strap between the subchassis and the goniometer capacitor housing at the housing (fig. 228).

(2) Remove the two rear screws which fasten the subchassis to the floating mount plate. Carefully slide the subchassis back and lift off the floating mount.

Note. The subchassis may be placed on its side beside the goniometer chassis during troubleshooting.

c. Reinstallation. Reassemble the goniometer as follows:

(1) Reinstall the subchassis by placing it in the floating mount and securing it with the two screws. Be sure the stud (panel end) anchors the subchassis and connects the ground strap.

(2) Carefully place the goniometer in the cabinet and fasten it with the panel screws and trim strips. Refer to figure 16 and complete all cable connections.

328. General Precautions

a. Controls. SUBCARRIER LEVEL control R18 and IDENTIFICATION LEVEL control R17 settings (fig. 229) may be changed as desired during troubleshooting. Do not change the settings of inductor L1 and L2 (fig. 230) during troubleshooting.

b. Short and B+ Checks. Before applying power for troubleshooting, use the multimeter to complete the checks shown in the chart below. All resistance measurements are between test point and chassis unless otherwise specified.

Test Point	Resistance (ohms)	Part checked
Pin 5, V3 (fig. 228)	Infinite	C16
Junction of R11 and C13 (fig. 230)	Infinite	C13
Pin 5, V2	Infinite	C12
Pin 6, V2	Infinite	C19
Pin 1, V1	Infinite	C4
Pin 6, V1	Infinite	C8
Between terminal 10 and 6 of receptacle J7 (fig. 228).	Infinite	C20

329. Bench Test Setup

a. General. The bench test setup illustrated in figure 182 is required when performing the troubleshooting procedures. The power supply should have good voltage regulation, a bleeder resistor across the output, and a power on-off switch. Set up the equipment as shown in A, figure 182, and connect the cables. Fabricate the power supply cable in accordance with connections shown in B, figure 182 to a convenient length (not over 6 feet).

b. Test Equipment. Before using the test equipment specified in paragraph 326 and shown in figure 182, consult the appropriate technical manual for operating and calibration procedures. Be extremely careful with test leads; use good quality low capacity shielded leads to avoid stray pickup.

330. Localizing Troubles

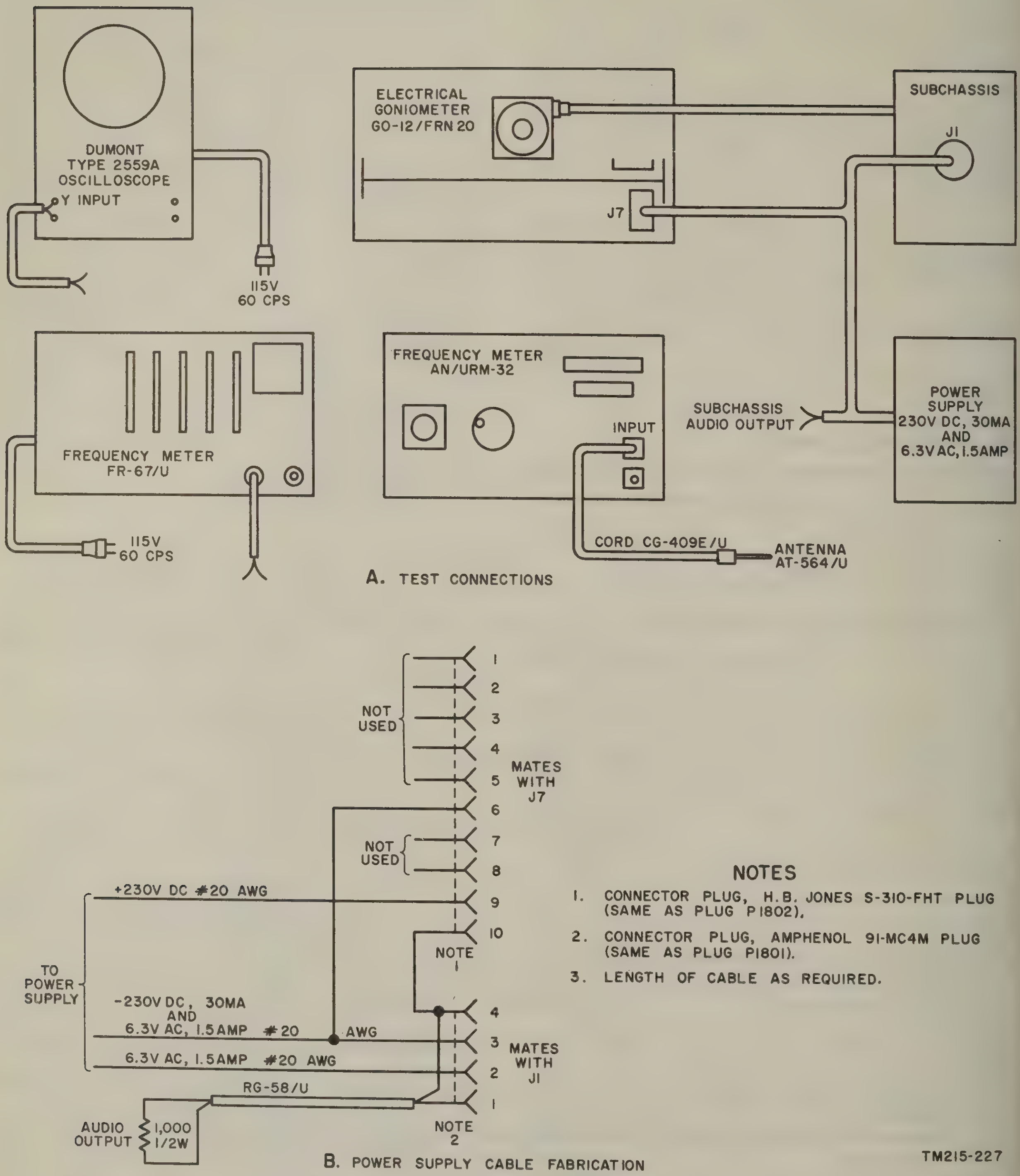
a. General. Troubleshooting the goniometer subcarrier chassis is divided into three sections: fixed oscillator, variable oscillator, and mixed signal circuits. Periodic checks of the power supply input to the subchassis should be made to insure adequate power during troubleshooting.

b. Operational Check. Energize the equipment as shown in A, figure 182 and visually inspect for malfunction or improper test connections. Connect the Y INPUT of the oscilloscope to the subchassis audio output leads and check for signal output. If there is no signal output, use Antenna AT–564/U as a probe and check with the RF meter for signals of 190.04 kc (pin 1, VI) and 200 kc (pin 6, VI) with the azimuth plate of the goniometer capacitor set at 90°. Operate the RF meter in accordance with instructions given in TM 11–5120.

c. Use of Chart. Refer to the *Indication* column for troubles indicated from operational check and reports. The *Probable trouble* and *Procedure* columns offer suggestions for isolating the defective part or parts.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	No subcarrier output at receptacle J1.	Output amplifier stage V3 (fig. 228) inoperative.	Check V3. Check tube V3 voltage and resistance (fig. 183).
		Mixer stage V2 inoperative	Check V2. Check tube V2 voltage and resistance (fig. 183).
		Fixed oscillator stage V1A inoperative.	Check V1. Check V1A voltage and resistance (fig. 183).
		Swept oscillator stage V1B inoperative.	Check V1. Check V1B voltage and resistance (fig. 183). Check coaxial line (P1, fig. 228) from capacitor C18 to swept oscillator for a short.
2	Subcarrier output at pin 1 of receptacle J1 not 9,960 cps with azimuth plate at 90°.	Fixed oscillator V1A off frequency	Check fixed oscillator frequency (par. 332*a*).
		Swept oscillator V1B off frequency	Check swept oscillator frequency (par. 332*a*).
		Both oscillators off frequency	Check frequency of both oscillators (par. 332*a*).
3	Subcarrier frequency deviation not ± 480 cps.	Goniometer capacitor C18 defective.	Replace complete goniometer capacitor (chapter 5).
4	Amplitude modulation on subcarrier output.	Voltage regulator V4 inoperative	Check or replace tube V4.
		Capacitor C4 or C8 (fig. 230) defective.	Check or replace capacitor C4 or C8.
5	Fixed oscillator and/or swept oscillator frequencies present in output at pin 1 of receptacle J1.	Defective bypass capacitors C12 and C13.	Check or replace capacitors.
		Shorted choke L3	Replace L3.



NOTES

1. CONNECTOR PLUG, H.B. JONES S-310-FHT PLUG (SAME AS PLUG P1802).
2. CONNECTOR PLUG, AMPHENOL 91-MC4M PLUG (SAME AS PLUG P1801).
3. LENGTH OF CABLE AS REQUIRED.

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Figure 182. Electrical Goniometer GO-12/FRN-20, bench test setup.

331. Signal Tracing

Use the chart below to assist in tracing the signals normally present in the subcarrier subchassis. Set the multimeter for ac operation and use the ac probe in accordance with the instructions given in TM 11–5511. Make measurements between the test point and chassis with the subchassis energized; use figure 278 as a circuit guide.

Test point	Ac voltage (volts)	Stage checked
Pin 1, V2 (fig. 230)	6±1	Fixed oscillator.
Pin 7, V2	7.6±1	Swept oscillator.
Pin 7, V3	2±.5	Mixer.
Pin 1, receptacle J1	0.5±.15	Output amplifier.

332. Frequency Check

a. Fixed and Swept Oscillators. Use the RF meter to check the frequency with the equipment set up and energized as shown in A, figure 182. Loosely couple the antenna hook to the cathode lead of the oscillator to be checked. The fixed oscillator frequency should be 190.04 kc ±1 kc. Check the swept oscillator frequency with the azimuth plate (fig. 30) set at 90° and 270° for 200 kc, 0° for 200.480 kc, and 180° for 199.520 kc (all frequencies ±1 kc). If oscillators check normal in all other respects, refer to the alinement section of chapter 5 for alinement procedure.

b. Subcarrier Output. Use the AF meter and the bench test setup shown in figure 182. Consult TM 11–2698 for the AF meter operating instructions and connect the input cable between pins 1 and 4 of receptacle J1 (fig. 228). Complete the following steps in the order given.

(1) Energize the equipment and allow it to stabilize. Set the azimuth plate to 90° and measure the frequency. The frequency should be 9,960 cps ±50 cps.

(2) Set the azimuth plate to 270° and measure the frequency. The frequency should be 9,960 cps ±50 cps.

Note. Frequencies measured at 90° and 270° must be within 10 cps of each other.

(3) Set the azimuth plate to 0° and measure the frequency. The frequency should be 10,440 cps ±24 cps.

(4) Set the azimuth plate to 180° and measure the frequency. The frequency should be 9,480 cps ±24 cps.

(5) If steps 1 through 4 above are out of tolerance, check both oscillator frequencies and/or replace the goniometer capacitor.

333. Isolating Troubles

a. Voltage and Resistance Measurements. When the defective stage has been located, the voltage and resistance measurements shown in figure 183 will be useful in locating the defective part. Resistance measurements are to be made with all external connections to the goniometer removed. Observe the notes on figure 183, contained in separate envelope, during all resistance and voltage measurements.

b. Goniometer Motor and Reactor L4.

(1) If motor B1 runs hot or fails to start, measure the resistance between terminals 1 and 2 of terminal board E1 (fig. 229). The resistance should be 35 ohms ±2 ohms. If it is low, check capacitor C21 for leakage or a short, or replace the motor. Check the resistance from terminal 2 to ground; the resistance should be infinite.

(2) The resistance of reactor L4 is 500 ohms ±10 ohms as measured between pins 9 and 10 of receptacle J7 (fig. 228). If the resistance is too high or low, replace it.

c. Repairs and Alinement. Refer to the instructions contained in chapter 5 when repairs or alinement are indicated.

Section XIII. INDICATOR PANEL SB–830/FRN–22A TROUBLESHOOTING

Warning: **Lethal voltages are present in the CY–2274/FRN–22A.**

334. General

The meter panel (fig. 233) is connected to the AM–1246/FRN–20 of each transmitting equipment through the CURRENT and LINE switches. The meter panel is more easily serviced on a test bench than in the cabinet.

335. Troubleshooting Reference Data

The following list of illustrations on chart will be useful when troubleshooting the meter panel.

Fig. No.	Caption
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
57	Indicator Panel SB–830/FRN–22A, control and indicator locations.
282	Indicator Panel SB–830/FRN–22A, schematic diagram.
301	Electrical Equipment Cabinet CY–2274/FRN–22A, wiring diagram.
305	Indicator Panel SB–830/FRN–22A, wiring diagram.

336. Equipment Required

a. Test Equipment. Only one piece of test equipment, Multimeter ME–77/U, is required. For instructions on use of the multimeter, see TM 11–6625–203–12.

b. Additional Equipment. A two-wire cord is required to supply 115-volt ac power during troubleshooting. It should consist of two #18 AWG insulated wires of suitable length, a connector at one end, which fits the available power outlet, and two terminal lugs at the other end for connection to terminal board TB1901 (fig. 233).

337. Removal and Reinstallation

To remove the meter panel from the CY–2274/FRN–22A, or to reinstall it, follow the instructions given below.

a. Removal. Disconnect the nine cabinet wiring leads from terminal board TB1901. Remove the two large screws at each end of the front panel and withdraw the meter panel.

b. Reinstallation. Insert the meter panel in the cabinet, replace the four screws, and reconnect the nine wires at the terminal board. Refer to figures 16 and 301 for wiring instructions.

338. Troubleshooting Procedures for Indicator Panel SB–830/FRN–22A

a. General. Troubleshooting the meter panel is divided into two sections: the current-measuring circuit and the frequency and voltage-measuring circuit. Refer to *b* or *c* below, depending on the trouble encountered.

b. Current-Measuring Circuit.

(1) With the meter panel on the test bench, disconnect the leads to CURRENT meter M1901, and connect the two leads together. This will prevent damage to the meter panel by the multimeter. Use the multimeter at the test points indicated and make the following continuity check.

Note. The multimeter indication should be 0 ohm for each test.

CURRENT switch S1901 position	Terminal board TB1901 test points
EQUIPMENT NO. 1 AMP TOTAL	10 to 6.
EQUIPMENT NO. 1 DRIVER TOTAL	10 to 7.
EQUIPMENT NO. 2 DRIVER TOTAL	10 to 8.
EQUIPMENT NO. 2 AMP TOTAL	10 to 9.

(2) As a short-to-ground check of switch S1901, perform the following test. Use the same test setup described in (1) above. A zero resistance indication on the multimeter indicates a short circuit in switch S1901; replace the switch.

Note. The multimeter should indicate infinite resistance.

CURRENT switch S1901 position	Terminal board TB1901 test points
EQUIPMENT NO. 1 AMP TOTAL	6 and chassis ground.
EQUIPMENT NO. 1 DRIVER TOTAL.	7 and chassis ground.
EQUIPMENT NO. 2 DRIVER TOTAL.	8 and chassis ground.
EQUIPMENT NO. 2 AMP TOTAL	9 and chassis ground.

(3) If the above checks prove satisfactory, the difficulty is in meter M1901. Replace the meter or send it to the supporting instrument shop for repair with information on the difficulty encountered.

c. Frequency and Voltage Measuring Circuit.

(1) With the meter panel on a test bench, and a convenient 115-volt, 60-cps supply available, make the tests indicated below. If an accurate 115-volt, 50-cps supply is available, the check should be accomplished with this supply also.

Warning: **Disconnect the 115-volt supply when changing the terminal board connections.**

Connections to TB1901	LINE switch S1902 position	M1903 Normal VOLTS	M1902 Normal FREQUENCY
2 and 4	EQUIPMENT NO. 1.	115	60 (50)
3 and 5	EQUIPMENT NO. 2.	115	60 (50)

Note. The FREQUENCY meter (M1902) when installed with the meter panel in the cabinet and operating with the other components, should indicate 50 cps when the omnirange site is supplied from a 60-cps source. Conversely, when the line power is 50 cps, meter M1902 should indicate 60 cps. After a warmup period, time-delay relay K902 in the O–371/FRN–20 shifts the input to the goniometer motor from omnirange site power (60 or 50 cps) to the regulated supply from the O–371/FRN–20 (at 50 or 60 cps). If the correct frequency is not indicated, and if relay K902 is functioning properly, replace or send meter M1901 to the supporting instrument shop for repair, tagged with information on the trouble.

(2) For a short-to-ground check of switch S1902, disconnect the 115-volt supply at TB1901. Set S1902 to EQUIPMENT NO. 1 position. Connect the multimeter between terminal 2 and ground of TB1901 to make a resistance measurement of S1902. A zero resistance indication on the multimeter indicates a short circuit in S1902, and it must be replaced.

Section XIV. KEYER KY–175/FRN TROUBLESHOOTING

Warning: **Dangerous voltages are present in the CY–1897/FRN–22. Take adequate precautions at all times to prevent electrical shock.**

339. General

Two keyers, one for each transmitting equipment, are located in the CY–1897/FRN–22 and connected electrically between their respective O–373/FRN oscillators and the RE–248/FRN–22. Although the keyer may be serviced in the cabinet, it is preferable to check it on a test bench for easier accessibility to its parts. Be sure to give the keyer a thorough visual inspection before applying power.

340. Troubleshooting Reference Data

The illustrations on chart listed below will be an aid when troubleshooting the keyer.

Fig. No.	Caption
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
33	Keyer KY–175/FRN, fuse and code and cycle wheel locations.
45	Alignment of code and cycle wheels with typical breakouts.
46	Data for cycle wheel breakouts.
284	Keyer KY–175/FRN, schematic diagram.
158	Modulating signal circuits, schematic diagram.
298	Electrical Equipment Cabinet CY–1897/FRN–22, wiring diagram.
306	Keyer KY–175/FRN, wiring diagram.

341. Equipment Required

Multimeter ME–77/U (TM 11–6625–203–12) is the only test equipment required to troubleshoot the keyer.

342. Removal and Reinstallation

Neither removal nor reinstallation requires any special procedures.

a. Removal. To remove the keyer from the CY–1897/FRN–22, disconnect the 115-volt ac line from receptacle J501 (fig. 236), and the input and output leads at terminals 1, 2, and 6 on terminal board TB501. Remove the trim strips and loosen the two screws (total of four) at each end of the front access panel. The keyer may then be withdrawn from the cabinet. To gain access to motor M501, motor-phasing capacitor C501, and resistors R502, R503, and R504 (fig. 235), loosen the knurled thumbscrew on each end of the front access panel. To obtain access to the gear train, switches S501 and S502, and code wheel W1 or cycle wheel W2 (fig. 236), loosen the two screws and remove the dust cover at the rear of the keyer.

b. Reinstallation. To reinstall the keyer, replace the dust cover and front access panel and tighten the two screws. Insert the keyer in the cabinet, tighten the screws at the ends of the access panel, and replace the cabinet trim strips. Connect the input and output leads to terminals 1, 2, and 6 on terminal board TB501 (fig. 236). Connect the 115-volt ac line to receptacle J501 if the keyer is serviceable.

343. General Precautions for Troubleshooting

Before applying power for troubleshooting, make a visual inspection to insure that fuse F501 is serviceable, connections at J501 and TB501 are securely made, the gear train is meshing properly, and that the contact arms and rollers on switches S501 and S502 are free to move.

344. Bench Test Setup

a. General. Connection of the keyer for bench testing is the same as shown in figure 284, except that the motor power supply may be any convenient 115-volt ac source instead of the RE–247/FRN–22 and there are no connections at terminal board TB501.

b. Cable Fabrication. No special leads are required for the test installation. A normal 115-volt ac male connector is needed at receptacle J501; the multimeter leads may be used to take measurements at terminal board TB501.

345. Troubleshooting Procedure

a. General. Troubleshooting the keyer, using the troubleshooting chart, involves the motor circuit, the gear-wheel-switch system, and R502, R503, and R504 (fig. 235).

b. Preliminary Operational Check. To insure a safe bench test setup, and while the keyer is warming up, check the keyer visually for smooth operation of motor M501, the gear train, and switches S501 and S502.

c. Chart Use. To use the troubleshooting chart, follow the steps in the order given, omitting those steps which are not applicable.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	No output	No power	Check 115-volt ac supply.
		Blown fuse (fig. 236)	Check F501.
		Inoperative motor (fig. 235)	Check M501.
		Open capacitor	Check C501.
		Gear teeth locked	Check gear train.
		Open switch	Check S501 and S502.
		Open resistor	Check R502, R503, and R504.
2	Erratic output	Intermittent power supply	Check power to J501.
		Motor cutting out	Check M501 and C501.
		Broken gear teeth	Inspect gear train teeth.
		W2 not rotating at 12 to 1 ratio	Check for gear slippage.
		Switch defective	Check S501 and S502.
		Broken code wheel segments	Inspect W1 segments.
		More than nine segments out of cycle wheel (fig. 109).	Inspect W2 segments.

Section XV. MODULATION ELIMINATOR MX–1843/FRN–20 TROUBLESHOOTING

346. General

The modulation eliminators, one for each transmitting equipment, are located in the CY–1899/FRN–22 cabinet and have self-contained power supplies. Service the modulation eliminator in the cabinet. Use the information in this section to obtain a complete and accurate diagnosis of troubles. To avoid additional damage or difficulties, be sure to complete the short and B+ tests (par. 350*b*) and perform a thorough visual inspection before applying power. If special repair procedures are required after the trouble has been located, refer to chapter 5.

347. Troubleshooting Reference Data

The following list of illustrations on chart will be useful when troubleshooting the modulation eliminator.

Fig. No.	Caption
11	Electrical Equipment Cabinet CY–1899/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
18	Modulation Eliminator MX–1843/FRN–20, tube and control locations.
31	Modulation Eliminator MX–1843/FRN–20, fuse and control locations.
277	Modulation Eliminator MX–1843/FRN–20, schematic diagram.
184	Modulation Eliminator MX–1843/FRN–20, bench test setup.
185	Modulation Eliminator MX–1843/FRN–20, voltage and resistance diagram.
209	Relay adjustment data sheet.
237	Modulation Eliminator MX–1843/FRN–20, interior view.
238	Modulation Eliminator MX–1843/FRN–20, rear view.
307	Modulation Eliminator MX–1843/FRN–20, wiring diagram.

348. Equipment Required

The test and other equipment needed to troubleshoot the modulation eliminator are listed below.

a. Test Equipment. The test equipment required for troubleshooting is listed below with the applicable technical manual and the assigned common name.

Test equipment	Technical manual	Common name
Audio Oscillator TS–382A/U.	TM 11–2684A	AF oscillator.
Electronic Multimeter TS–505/U.	TM 11–5511	Vtvm.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Oscilloscope, DuMont, Type 2559A.		Oscilloscope.
Radio Frequency Wattmeter AN/URM–43A.	TM 11–5133	Wattmeter.

b. Additional Equipment Required. Additional equipment required to troubleshoot the modulation eliminator is listed below with its common name.

Quantity	Description	Technical literature	Common name
3	Safety door switch (cap portion) Bryant Electric Co. No. 4600A (Federal Stock No. 5930–757–4130).	None	Interlock jumper plug.
1	Radio Transmitter T-573/FRN–20	Sect. XXII	Transmitter.
1	Power Supply PP–1331/FRN–20	Sect. XVII	
1	Cable, bench test, between power supply and transmitter	Par. 351	Test cable.
1	Cable, bench test to J5	Par. 351	Test cable.
1	Loop, oscilloscope pickup	Par. 351	Pickup loop.
1	Cable, coaxial	Par. 351	Coaxial test cable.

349. Removal and Reinstallation

If it is necessary to remove the modulation eliminator from the cabinet, proceed as follows:

a. Removal. Open the rear door of the CY–1899/FRN–22 and remove plugs P1804, P1805, P1, and P1814 (fig. 16) from the modulation eliminator. Remove plug P14 from the goniometer. Remove the trim strips and the four screws at the sides of the front access panel. Withdraw the modulation eliminator from the cabinet.

***Warning:* Before removing the plugs from the modulation eliminator, be sure that the transmitter is not operating.**

b. Reinstallation. Install the modulation eliminator in the cabinet, tighten the four screws on the front panel, and replace the cabinet trim strips. Connect the plugs to their proper receptacles (fig. 16).

350. General Precautions

a. Controls. One screwdriver adjustment (R9 for the side band level, fig. 237) is located behind an access hole in the front panel. Another screwdriver adjustment (C7 for adjustment of output resonant frequency, fig. 238) is located at the rear of the modulation eliminator. Do not change either of these settings during troubleshooting unless specifically told to do so in this section.

***Warning:* Always shut the transmitter off before adjusting C7. The adjustment for C7 is located near the output tank coil of the transmitter which can cause an RF burn without physical contact.**

b. Short and B+ Test. Before applying power, inspect the modulation eliminator visually to insure that the interlock switch is serviceable, receptacles for power input and output are in working order, and that all tubes are properly seated in their sockets. With the modulation eliminator disconnected, and using figures 277 and 237 as a reference, test for a short circuit in the B+ circuit by measuring with the multimeter between the junction of resistors R2 and R6 and chassis ground. A value of 25,000 ohms should be obtained. If any other value is obtained, check resistor R6 and capacitors C2 (fig. 237), C5, C6, C10, C11, and C12 (fig. 238) for a defect before applying power.

351. Bench Test Setup

If it is necessary to remove the modulation eliminator from the cabinet, the following test setup will apply.

a. General. The test setup for the modulation eliminator is shown in figure 184. The test equipment is adjusted in accordance with the respective technical manual listed in paragraph 348*a*. Power Supply PP–1331/FRN–20 is adjusted in accordance with the procedure outlined in paragraph 38. The transmitter is adjusted in accordance with the procedure outlined in paragraph 39, except that the wattmeter should be connected to receptacle J1 (fig. 238) on the modulation eliminator, and the ANTENNA LOADING control (par. 39*q*) is adjusted for a 40-watt output indication on the wattmeter.

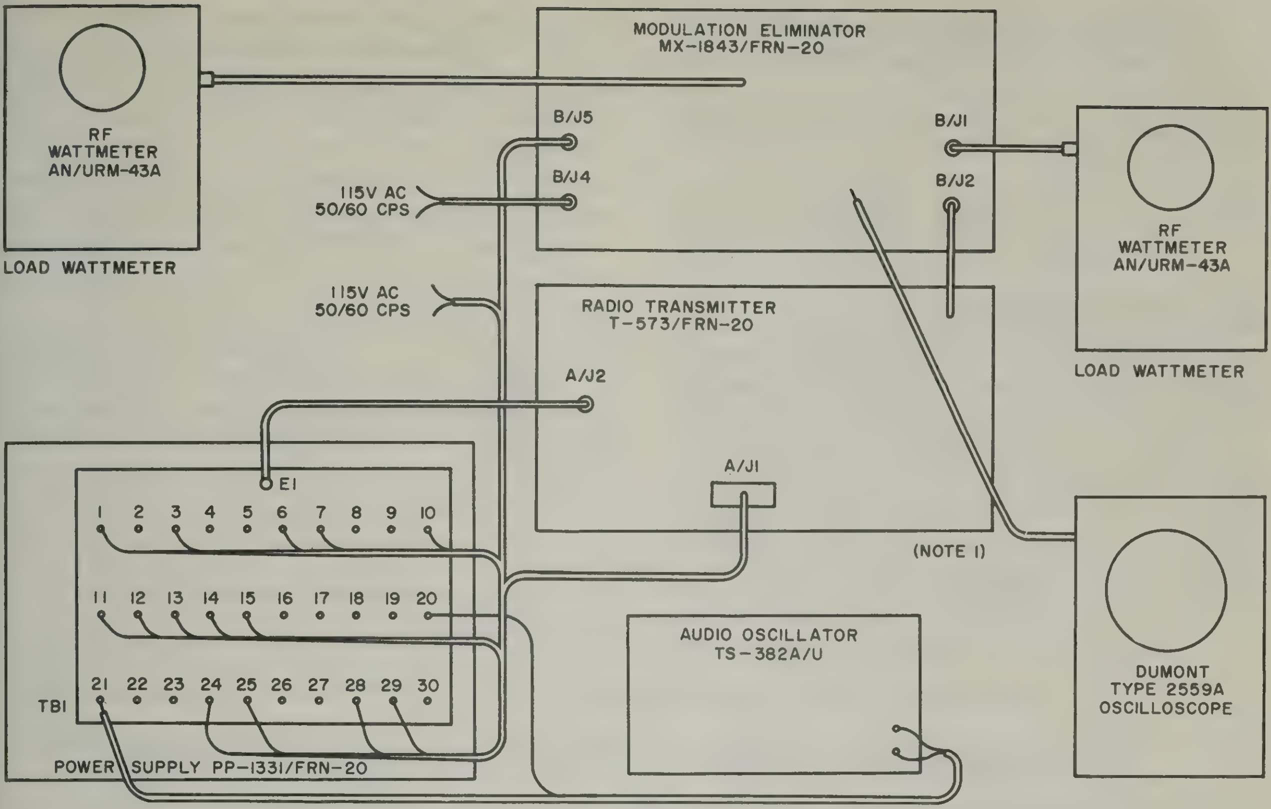
b. Cable Fabrication. Connecting leads for the AF oscillator, vacuum-tube voltmeter, multimeter, and oscilloscope are furnished with the test equipment. The connections for the PP–1331/FRN–20, the transmitter, the modulation eliminator, the wattmeter, and the oscilloscope must be fabricated as indicated in the following chart.

Item and use	Wire size	Length
Jumper wire between terminals 28 and 29 of TB1.	#18 AWG	2 in.
Electrical plug connector, James Millen Co. part No. 37001 (Federal Stock No. 5935–259–6810) (plug) at J2 of transmitter.		
Electrical plug connector, Howard B. Jones Co. part No. S–315–FHT (Federal Stock No. 5935–295–4825) at J1 of transmitter.		
Electrical plug connector UG–21B/U at J1 for wattmeter connection.		
Electrical plug connector, American Phenolic Corp. part No. (Federal Stock No. 5935–376–9307) 91–MC4M at J5.		
Electrical plug connector, General Electric Co. part No. GE–4317–1 (Federal Stock No. 5935–665–4406) at J4.		
Electrical plug connector UG–88/U at oscilloscope for pickup cable.		
Wire for connections between J1 of transmitter and TB1 of PP–1331/FRN–20 (separate the two units about 2 feet).	#18 AWG	22 ft.
Wire connections between J5 of modulation eliminator and TB1 of PP–1331/FRN–20.	#18 AWG	10 ft.
Wire for connections between J2 of transmitter and TB1 of PP–1331/FRN–20.	#18 AWG (high voltage).	3 ft.
Coaxial cable for connections between J1 of modulation eliminator and wattmeter.	RG–8/U	5 ft.
Coaxial cable pickup for oscilloscope. Strip back rubber insulation and shield approximately 4 in. on one end.	RG–8/U	5 ft.
Wire, for connections between J4 and the 115-volt ac source.	#14 AWG	5 ft.
Wire, for connections between terminals 24 and 25 of TB1 and the 115-volt ac source.	#14 AWG	5 ft.

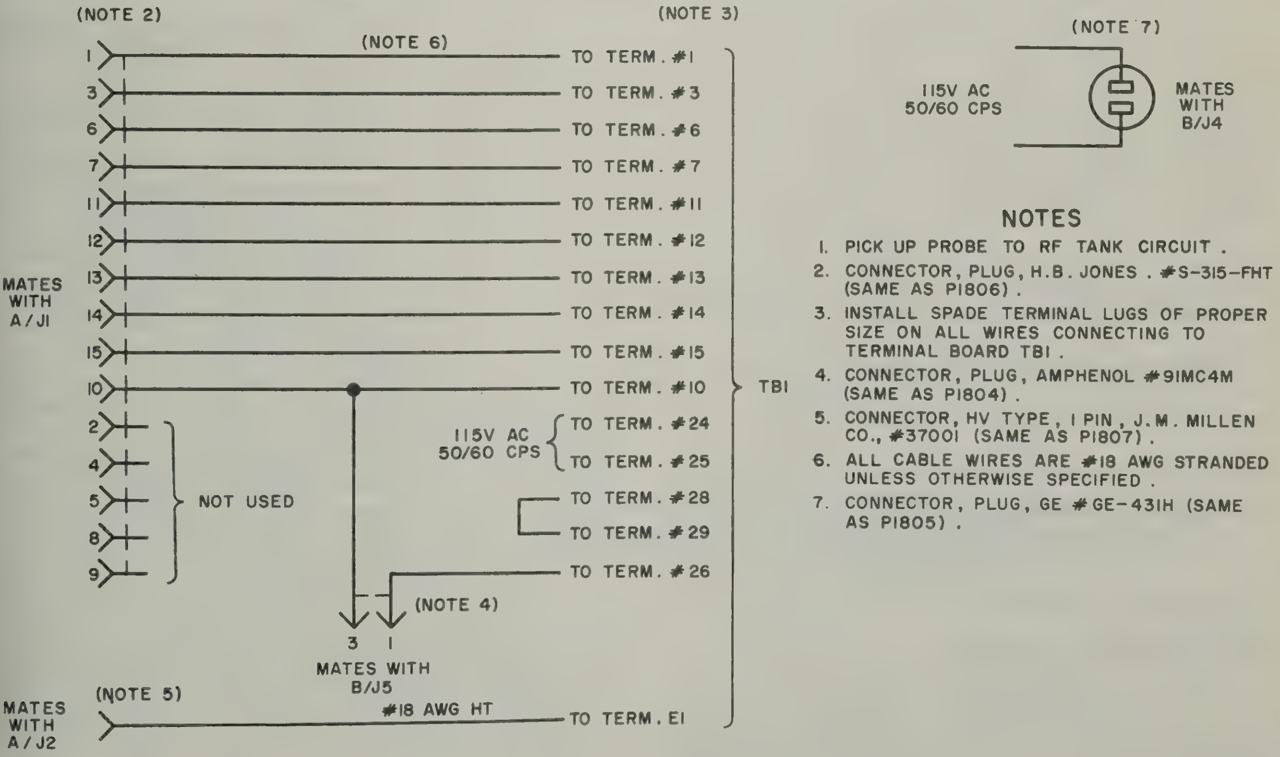
c. Modulation Eliminator Signal Voltage. When bench testing, use the transmitter and PP–1331/FRN–20 to obtain sufficient power for a proper check.

d. Test Procedure. If a bench test is necessary, proceed as follows:

(1) Remove the components from the cabinet (par. 349).



A. TEST CONNECTIONS



NOTES

1. PICK UP PROBE TO RF TANK CIRCUIT.
2. CONNECTOR, PLUG, H.B. JONES. #S-315-FHT (SAME AS P1806).
3. INSTALL SPADE TERMINAL LUGS OF PROPER SIZE ON ALL WIRES CONNECTING TO TERMINAL BOARD TB1.
4. CONNECTOR, PLUG, AMPHENOL #91MC4M (SAME AS P1804).
5. CONNECTOR, HV TYPE, 1 PIN, J.M. MILLEN CO., #37001 (SAME AS P1807).
6. ALL CABLE WIRES ARE #18 AWG STRANDED UNLESS OTHERWISE SPECIFIED.
7. CONNECTOR, PLUG, GE #GE-431H (SAME AS P1805).

B. CABLE FABRICATION

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Figure 184. Modulation Eliminator MX-1843/FRN-20, bench test setup.

(2) Connect the components and test equipment as indicated in the test setup (fig. 184).
(3) Connect the necessary jumpers and loads (fig. 184).
(4) Install the interlock jumper plugs.
(5) Apply 115 volts ac to terminals indicated (fig. 184).

352. Localizing Troubles

a. General. Troubleshooting the modulation eliminator by using the following chart provides a systematic check to isolate a defective part.

b. Preliminary Operational Check. To prevent the introduction of additional troubles when using the bench test setup, check the setup for secure and proper connections (fig. 184). Turn on the equipment and closely observe the units for such defects as overheating and smoking components, cold tubes, or blown fuses. If the modulation eliminator has no output when mounted in the cabinet, but functions properly on the test bench, power relay K1 (fig. 237) may not be energizing. In this case, check the wiring between receptacle J5 and the RE–248/FRN–22 (figs. 298 and 299 or 300 and 303).

c. Use of Chart. To use the chart, check the *Indication* column for the trouble symptoms observed, note the probable troubles that may exist, and apply the corrective procedure given for that trouble, observing all paragraph references.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	V1, V2, V3, and V4 filaments do not light.	Blown fuse or defective interlock	Check F1 and S1 (fig. 237).
2	V1, V2, and V3 filaments do not light.	Defective transformer	Check 6.3-volt winding (par. 353*b*).
3	V4 filament does not light	Defective transformer or tube	Check 5-volt winding (par. 353*b*). Check V4 (fig. 238).
4	Low, or no, output	Low or no B+	Check V4. Check C10 and C12. Check K1. If energized, check contacts. Make voltage and resistance measurements at V4 (fig. 185).
		Defective carrier amplifier or output stage.	Check V1. Make voltage and resistance measurements at V1. Check capacitor C5 for an open. Check capacitors C7 and C8. Check inductor L3 (par. 353*b*). Check tube V2 for gas. Check adjustment of R9.
5	High output	R9 misadjusted	Readjust R9 (par. 46 ch. 2). Check V2 by substitution. Check resistor R2.
6	Output contains modulation greater than 5%.	Defective tube	Check V2 and V3. Make voltage and resistance measurements at V2 and V3. Check capacitor C5 for an open. Check adjustment of R9.
7	Meter indicates wrong values	Defective meter	Check and replace meter M1.
8	Meter indicates wrong value on an individual switch position.	Shunt resistor defective	Check resistor R7, R8, or R10. Check switch S2.

353. Isolating Trouble

a. Voltage and Resistance Measurements. Before referring to figure 185, contained in separate envelope, read the notes carefully to duplicate the test conditions. The voltage and resistance measurements in figure 172 are used to assist in isolating faulty parts after a defective stage has been located. When the defective part is located, check all associated parts to determine whether another part caused the failure. A shorted capacitor can overload an associated resistor.

b. Transformer and Inductor Resistance. The dc resistances in the chart below are used to isolate a transformer or inductor that is open or shorted.

Transformer or inductor	Connection points	Resistance (ohms)
E1 (fig. 238)	Across leads	Less than 1.
L1	Across leads	Less than 1.
L2	Across leads	Less than 1.
L3	Across leads	Less than 1.
L4	Across leads	Less than 1.
L5	Across leads	Less than 1.
L6	Across leads	130.
T1	0–115	8.
	Across 275-volt winding.	75.
	Across 5-volt winding	Less than 1.
	Across 6.3-volt winding	Less than 1.

354. Additional Troubleshooting Data

a. Tube Substitution. Sometimes, even though tubes may have been tested with the tube tester, it is necessary to substitute one or more tubes to be sure that a tube is not the cause of trouble in a defective stage. Never leave a new tube in the socket if the modulation eliminator operates satisfactorily with the original tube.

b. Parts Substitution. Another procedure to use for hard-to-find difficulties is to substitute parts that are known to be functioning properly for suspected parts. Be sure to disconnect the suspected part before connecting the known temporary part. Do not leave the new part in the modulator eliminator unless it corrects the difficulty.

c. Repair and Test. For instructions on special techniques used to repair the modulation eliminator, see chapter 5. For the final test procedures, refer to chapter 6.

Section XVI. POWER SUPPLY PP–1329/FRN–20 TROUBLESHOOTING

***Warning:* Extremely high voltages are present in this equipment when power is applied. Avoid physical contact with exposed parts and terminals.**

355. General

a. Troubleshooting of the PP–1329/FRN–20 is best undertaken at the test bench, but it may be carried out with the PP–1329/FRN–20 in place in the equipment cabinet, when necessary. Since this power supply weighs 177 pounds, its removal from the cabinet should not be attempted without help and unless it is absolutely necessary.

b. The PP–1329/FRN–20 supplies high voltages to the AM–1246/FRN–20. There is one such power supply for each transmitting equipment. Troubleshooting the PP–1329/FRN–20 consists mainly of the measurement of input voltages, output voltages, ripple content of output voltages, resistances of parts, checking tubes, and replacement of defective tubes or parts.

356. Troubleshooting Reference Data

The following list of illustrations will be helpful when troubleshooting the PP–1329/FRN–20.

Fig. No.	Caption
11	Electrical Equipment Cabinet CY–1899/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
21	Power Supply PP–1329/FRN–20, tube, fuse, and thermal relay locations.
239	Power Supply PP–1329/FRN–20, fuse locations.
281	Power Supply PP–1329/FRN–20, schematic diagram.
186	Power Supply PP–1329/FRN–20, bench test setup.
187	Power Supply PP–1329/FRN–20, voltage and resistance diagram.
239	Power Supply PP–1329/FRN–20, interior view.
240	Power Supply PP–1329/FRN–20, rear view.
241	Relay adjustment data.
308	Power Supply PP–1329/FRN–20, wiring diagram.

357. Equipment Required

a. Test Equipment. Test equipment required for troubleshooting is listed below with the applicable technical manual and common name.

Test equipment	Technical manual	Common name
Electronic Multimeter TS–505/U.	TM 11–5511	Vtvm.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment Required. Additional equipment required for troubleshooting the PP–1329/FRN–20 is listed below with its common name.

Qty	Description	Common name
1	Tool Equipment TE–113	Tool kit.
3	Safety door switch (cap portion) Bryant Electric Co. No. 4600A (Federal Stock No. 5930–757–4130).	Interlock jumper plug.
1	Bench test cable (par. 360*c*)	Test cable.
1	5,000-ohm, 75-watt wire-wound resistor.	500-volt load.
2	100,000-ohm 2-watt resistors	Load resistors.
2	20,000-ohm 150-watt wire-wound resistors.	1,350-volt load.
2	2-μf 3,000-volt dc capacitors	Blocking capacitor.

358. Removal and Reinstallation

a. Removal. The PP–1329/FRN–20 weighs 177 pounds; do not attempt to remove it from the cabinet without assistance. Proceed as follows:

(1) Disconnect plug P1808 from receptacle J1401 (fig. 16). Detach the plate caps from terminals E1801 and E1802 at the side of the cabinet (fig. 16).

(2) Remove the cabinet trim strips by prying them out from the trim strip clips with a screwdriver.

(3) Station a helper at the rear of the cabinet to hold the chassis while the chassis mounting screws are removed. The chassis must not be allowed to tilt down into the cabinet bottom while the mounting screws are being removed.

(4) Remove the chassis mounting screws, beginning at the top.

(5) Hold the bottom of the panel in place while the bottom screws are removed and the helper holds the chassis in place.

(6) Draw the chassis forward, out of the cabinet. The helper should lift the chassis rear edge clear of the opening and help support the chassis as it is lowered to the floor.

b. Reinstallation. To replace the PP–1329/FRN–20, proceed as follows:

(1) Place the unit on the floor in front of the cabinet.

(2) Have the helper lift the rear edge of the chassis clear of the opening.

(3) Have the helper apply backward pressure to the chassis while the mounting screws are being replaced from the bottom up.

(4) Replace the cabinet trim strips, and tap them onto the mounting clips with a rubber mallet or padded hammer.

359. General Precautions

***Warning:* Observe standard safety precautions when measuring high voltages, and when working where interlocks are disabled.**

a. When troubleshooting this power supply, make repairs discovered by visual inspection or from other sources before applying power. Repair all defects as they are discovered before continuing with bench tests or troubleshooting. If there are defects, or indications of defects which might cause damage if power is applied, *do not* apply power until these defects are corrected.

b. Servicing the PP–1329/FRN–20 in the cabinet requires disabling of interlocks S1803 and S1804 (fig. 226) with interlock jumper plugs. When the front panel is removed, interlock S1402 (fig. 239) must also be disabled with a jumper plug. Be careful when these interlocks are disabled, because they no longer protect personnel from the high voltages present within the units.

(1) Power to the PP–1329/FRN–20 is controlled by main circuit breaker K1001 and circuit breaker K1011 (for equipment No. 1) or K1012 (for equipment No. 2)

(2) When K1001 is closed, 115-volt ac power

is applied to the relay circuits of the PP–1329/FRN–20 when 9 is dialed for equipment No. 1 or 7 for equipment No. 2. Be sure that *all* power is removed before troubleshooting. Dial 10 and open K1011 or K1012, whichever is applicable.

360. Bench Test Setup

a. The bench test setup for the PP–1329/FRN–20 is shown in figure 186. Remove the front panel by loosening the captive thumbscrew at each corner. Install an interlock jumper plug in S1402.

b. Power sources of 115 volts ac and 230 volts ac at 50 to 60 cps with switching facilities to control application of power are required.

c. Make up a test cable to provide power to the component and connections for test equipment as follows (length as required):

(1) Use plug connector AN/3106B–36–1S for connection to receptacle J1401 of the PP–1329/FRN–20.

(2) Use a suitable plug to mate with the available ac power outlet.

(3) Make connections as shown in the following chart:

Terminal	Connected to	Use wire size
G	230-volt ac source	#14 AWG.
H	500-volt load resistor (5,000-ohm 75-watt).	#18 AWG.
J	500-volt load resistor and dc blocking capacitor.	#18 AWG.
M	To terminal U	#18 AWG.
N	To terminal V	#18 AWG.
S	230-volt ac source	#14 AWG.
U	115-volt ac source (and terminal M).	#14 AWG.
V	115-volt ac source (and terminal N).	#14 AWG.

d. Complete the test bench setup as follows:

(1) Provide a suitable mounting for the 5,000-ohm 75-watt resistor (500-volt load), one 2-microfarad 3,000-volt capacitor (blocking capacitor), and one 100,000-ohm 2-watt resistor.

(2) Join one lead of the 100,000-ohm and 5,000-ohm resistors and connect this junction to terminal H of the test cable plug.

(3) Join one terminal of the blocking capacitor to the remaining lead of the 5,000-ohm resistor and connect this junction to terminal J of the test cable plug.

(4) Connect the remaining terminal of the blocking capacitor to the remaining lead of the 100,000-ohm resistor.

(5) Provide a suitable mounting for two 20,000-ohm 150-watt resistors (1,350-volt loads), one 100,000-ohm resistor, and one 2-microfarad blocking capacitor.

(6) Join together one terminal of each 1,350-volt load resistor to one lead of the 100,000-ohm resistor. Connect this junction to the power supply chassis with #14 AWG wire.

(7) Connect each free end of the 1,350-volt load resistors to transformer T1403; one to terminal 5, the other to terminal 9, using #14 AWG wire.

(8) Connect the free end of the 100,000-ohm resistor to the 2-microfarad blocking capacitor.

(9) Connect the remaining lead of the blocking capacitor to terminal 7 of T1403 using #14 AWG wire.

361. Preliminary Bench Test Procedure for Power Supply PP–1329/FRN–20

a. Preliminary procedures for bench tests are:

(1) Make a visual inspection and repair the defects.

(2) Insert the interlock jumper plug at S1402, and check the bench test setup to be sure that the connections shown in figure 186 are correctly made.

(3) Apply power. Be alert for signs of overload or defects such as overheating, fuses blowing, and suspicious sounds or smells. Turn off the power *immediately* if there are such indications.

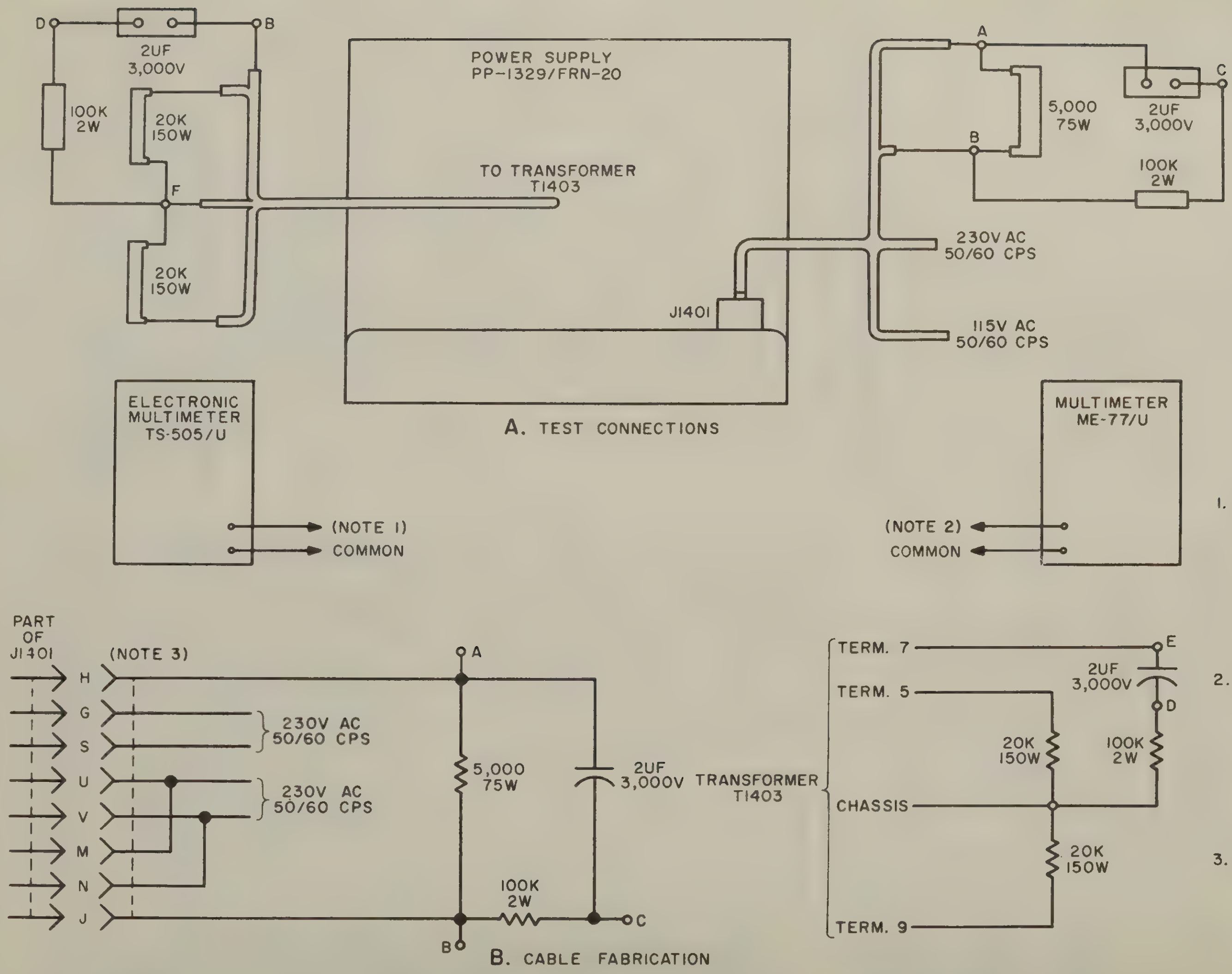
b. Make the following operational test:

(1) Apply power and listen for the closing of K1401 (fig. 239) as soon as power is applied, S1401 (fig. 240) 24 to 36 seconds later, and K1402 (fig. 253) immediately after S1401.

(2) Observe tube filaments.

362. Troubleshooting Chart

With the operational test (par. 361) and visual inspection as a starting point, difficulties in the PP–1329/FRN–20 can be localized and corrected by the following procedures.



NOTES

1. FOR AC RIPPLE MEASUREMENTS USE ELECTRONIC MULTIMETER TS-505/U.
   TEST #1 RANGE 40V AC
      CONNECT COMMON PROBE TO TEST POINT B AND MEASURE FROM TEST POINT C.
   TEST #2 RANGE 100V AC
      CONNECT COMMON PROBE TO TEST POINT F. AND MEASURE FROM TEST POINT D.
2. FOR OUTPUT VOLTAGE MEASUREMENTS USE MULTIMETER ME-77/U.
   TEST #1 RANGE 1000V DC
      CONNECT COMMON PROBE TO TEST POINT B AND MEASURE FROM TEST POINT A.
   TEST #2 RANGE 5,000V DC
      CONNECT COMMON PROBE TO TEST POINT F AND MEASURE FROM TEST POINT E.
3. CONNECTOR PLUG AN-3106B-36 IS (SAME AS P1808).

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Figure 186. Power Supply PP–1329/FRN–20, bench test setup.

Item	Indication	Probable trouble	Procedure
1	Filaments do not light	Open fuse	Check fuses F1401, F1402, F1403, and F1404 (fig. 240).
		Defective relay	Check relay K1401 coil (fig. 239) and contact adjustment (fig. 241).
		Defective transformer	Check transformer T1401 (par. 363*b*).
2	No output from either 500-volt or 1,350-volt circuits.	Open fuse	Check fuses F1408 and F1409.
		Defective thermal relay	Check thermal relay S1401 by substitution. Check interlock switch S1402.
		Defective plate relay	Check relay K1402 coil and contact adjustment (fig. 255).
		Defective transformer	Check transformer T1402 (par. 363*b*).
3	No output from 1,350-volt circuit (500-volt output normal).	Open fuse	Check fuse F1411 (fig. 239).
		Defective tube	Check V1401 and V1402.
		Filter circuit defective	Check reactors L1403 and L1404 (par. 363*b*). Check capacitors C1403 and C1404. Check resistor R1402 (fig. 239).
4	No output from 500-volt circuit (1,350-volt output normal).	Open fuse	Check fuse F1410. Check V1403. Check reactors L1401 and L1402 (par. 363*b*). Check capacitors C1401 and C1402. Check resistor R1401.
5	Low output from both supplies	Transformer defective	Check transformer T1402 resistance and voltages (par. 363*b*).
6	Low output from 1,350-volt supply	Transformer defective	Check transformer T1402 voltage. Check T1402 resistance.
		Filter capacitor leaky	Check C1403 and C1404 for leakage.
7	Low output from 500-volt supply	Filter capacitor leaky	Check C1401 and C1402 for leakage.
8	Excessive ripple voltage on 1,350-volt supply.	Filter reactor shorted	Check L1403 and L1404 resistance.
		Filter capacitor open	Check C1403 and C1404 capacity.
9	Excessive ripple voltage on 500-volt supply.	Filter reactor shorted	Check L1401 and L1402 resistance.
		Filter capacitor open	Check C1401 and C1402 capacity.

363. Voltage and Resistance Measurements

a. Voltage and resistance measurements are shown in figure 187, contained in separate envelope. Data for these measurements are given in the notes which form a part of the diagram.

b. Dc resistance of transformer and reactor windings are given in the following chart. Components must be completely isolated from other components before measuring the resistance.

Transformer or reactor	Connection points	Resistance (ohms)
L1401 (fig. 239)	Across leads	190
L1402	Across leads	190
L1403	Across leads	105
L1404	Across leads	120
T1401	1–3	19
	2–4	21
	5–7	Less than 1
	8–10	Less than 1
T1402	1–2	Less than 1
	1–4	1. 4
	3–4	Less than 1
	5–6	60
	5–7	84
	5–8	108
	5–9	170
T1403	1–2	Less than 1
	3–4	Less than 1
	5–7	84
	5–9	170

Section XVII. POWER SUPPLY PP–1331/FRN–20 TROUBLESHOOTING

Warning: **Extremely dangerous voltages are present when power is applied. Avoid physical contact with exposed parts and terminals. Observe safety precautions when measuring high voltages.**

364. General

a. The PP–1331/FRN–20 furnishes +500 volts dc, +250 volts dc, –25 volts dc, and –75 volts dc to Radio Transmitter T–573/FRN–20. The PP–1331/FRN–20 also furnishes 6.3 volts ac and +250 volts dc to the goniometer. Plus 12 volts dc is provided for operation of internal relay S5, the carrier control relay (fig. 242), and to the RE–248/FRN–22.

b. Troubleshooting the PP–1331/FRN–20 is best undertaken at the test bench, but this equipment may be serviced in the cabinet if necessary. The unit weighs 105 pounds; do not attempt to remove it from the cabinet without help.

365. Troubleshooting Reference Data

The following list of illustrations will be helpful when troubleshooting the PP–1331/FRN–20.

Fig. No.	Caption
11	Electrical Equipment Cabinet CY–1899/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
20	Power Supply PP–1331/FRN–20, tube, control, and thermal relay locations.
276	Power Supply PP–1331/FRN–20, schematic diagram.
188	Power Supply PP–1331/FRN–20, bench test setup.
189	Power Supply PP–1331/FRN–20, voltage and resistance diagram.
208	Relay adjustment data.
242	Power Supply PP–1331/FRN–20, interior view.
243	Power Supply PP–1331/FRN–20, rear view.
299	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 1 wiring diagram.
300	Electrical Equipment Cabinet CY–1899/FRN–22, equipment No. 2 wiring diagram.
309	Power Supply PP–1331/FRN–20, wiring diagram.

366. Equipment Required for Troubleshooting

a. Test Equipment. Test equipment required for troubleshooting the PP–1331/FRN–20 is listed below with the technical manual and the assigned common name.

Test equipment	Technical manual	Common name
Electronic Multimeter TS–505/U.	TM 11–5511	vtvm.
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Electron Tube Test Set TV–2/U or	TM 11–2661	TV–2/U.
Electron Tube Test Set TV–7/U.	TM 11–5083	TV–7/U.

b. Additional Equipment. Additional equipment required for troubleshooting the PP–1331/FRN–20 is listed below with its common name.

Qty	Description	Common name
1	Safety door switch (cap portion) Bryant Electric Co. No. 4600A (Federal stock No. 5930–757–4130).	Interlock jumper plug.
1	Bench test cable (fig. 188)	Test cable.
1	2,200-ohm 200-watt wire-wound resistor.	500-volt load.
1	1,450-ohm 50-watt wire-wound resistor.	250-volt load.
1	8,400-ohm 1-watt resistor	–25-volt load.
1	9,400-ohm 1-watt resistor	–75-volt load.
2	0.5-µf 600-volt capacitors	Blocking capacitors.
1	Tool Equipment TE–113	Toolkit.
12 ft	#18 AWG stranded wire	

367. Removal and Reinstallation

a. Removal. With the aid of an assistant, perform the following procedures to remove the PP–1331/FRN–20 from the cabinet.

(1) Disconnect the cabinet wiring from terminal board TB1 (fig. 243), and check identification of each wire to be sure that information is available for proper reconnection (fig. 16).

(2) Remove the cabinet trim strips by prying them up from the trim strip clips with a screwdriver.

(3) With an assistant at the rear of the cabinet to hold the chassis in place, remove

the chassis mounting screws, beginning at the top of the chassis flange.

(4) With the bottom screws removed, have the assistant lift the chassis to tilt the top edge out, while drawing the chassis backward to keep the bottom of the panel in place in the cabinet front.

(5) Grasp the exposed edges of the chassis when the assistant tilts the top out.

(6) Hold the chassis in place, while the assistant moves to the front to help lift the chassis out of the cabinet.

b. Reinstallation. To reinstall the PP–1331/FRN–20 in the cabinet, proceed as follows:

(1) With an assistant, lift the chassis to the cabinet opening and slide it into place.

(2) Station the assistant at the rear to hold the chassis in place, while the chassis mounting screws are being replaced.

(3) Replace the chassis mounting screws, beginning at the bottom of the chassis flange.

(4) Replace the cabinet trim strips by hooking one lip over the edge of the trim strip clips and tapping lightly with a rubber mallet or padded hammer.

(5) Replace the wiring to terminal board TB1. Check identification of each wire to assure proper reconnection (fig. 24).

368. General Precautions

a. Observe standard safety precautions when measuring high voltages and working where interlocks are disabled.

b. Repair all faults discovered by visual inspection or other sources before applying power. While troubleshooting, repair all defects as they are discovered before continuing with bench tests or troubleshooting. Do not apply power if there are defects, or indications of defects, that might cause damage.

369. Bench Test Setup

a. The bench test setup for the PP–1331/FRN–20 is shown in figure 188.

b. Set up the chassis on the test bench in the position in which it is normally installed in the cabinet.

c. The bench test requires a 115-volt 50- to 60-cps ac power source with adequate switching facilities to control the application of power.

d. Test connections for bench testing the PP–1331/FRN–20 are shown in B, figure 188.

e. To complete the bench test setup, provide a suitable mounting for the 2,200-ohm 200-watt and 1,450-ohm 50-watt resistors, and the two 0.05-microfarad capacitors. The two resistors should lie parallel, close together, with one capacitor on each side.

370. Preliminary Bench Test Procedures

a. Preliminary bench testing procedures are as follows:

(1) Remove the front panel by loosening the captive thumbscrew at each edge of the panel.

(2) Insert the interlock jumper plug in S1 (fig. 243). Check the bench test setup (fig. 188) to be sure that connections are correctly made. Set S2 to ON.

(3) Make a thorough visual inspection and repair any defects.

(4) Apply power and be alert for signs of overload such as overheating, fuses blowing, and suspicious sounds or smells. Turn off power immediately if there are any indications of overload.

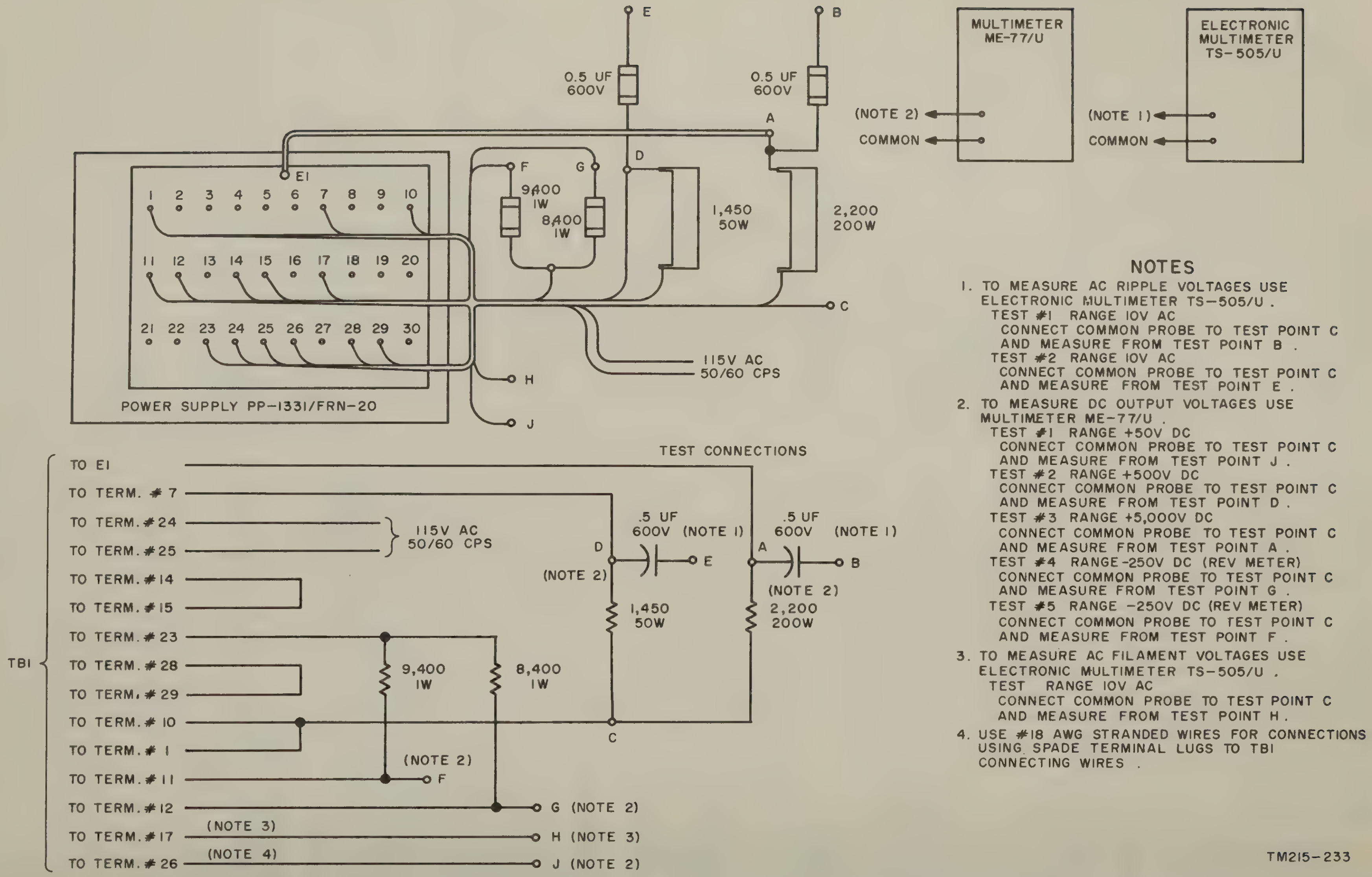
b. Make the following operational test:

(1) Apply power and listen for relays closing. Relay S5 will close as soon as power is applied, S4 shortly after, and S3 between 24 and 36 seconds after power is applied.

(2) Observe tube filaments for lighting.

371. Troubleshooting Chart

With the operational test (par. 370*b*) and bench test measurements (fig. 188) as a starting point, difficulties in the PP–1331/FRN–20 can be isolated by following the procedures given in the following chart.



NOTES

1. TO MEASURE AC RIPPLE VOLTAGES USE ELECTRONIC MULTIMETER TS-505/U.
   TEST #1 RANGE 10V AC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT B.
   TEST #2 RANGE 10V AC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT E.
2. TO MEASURE DC OUTPUT VOLTAGES USE MULTIMETER ME-77/U.
   TEST #1 RANGE +50V DC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT J.
   TEST #2 RANGE +500V DC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT D.
   TEST #3 RANGE +5,000V DC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT A.
   TEST #4 RANGE -250V DC (REV METER)
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT G.
   TEST #5 RANGE -250V DC (REV METER)
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT F.
3. TO MEASURE AC FILAMENT VOLTAGES USE ELECTRONIC MULTIMETER TS-505/U.
   TEST RANGE 10V AC
   CONNECT COMMON PROBE TO TEST POINT C AND MEASURE FROM TEST POINT H.
4. USE #18 AWG STRANDED WIRES FOR CONNECTIONS USING SPADE TERMINAL LUGS TO TB1 CONNECTING WIRES.

Figure 188. Power Supply PP–1331/FRN–20, bench test setup.

Item	Indication	Probable trouble	Procedure
1	No voltages present at any output terminal after 36-second delay after applying power.	Open fuse	Check fuses F1 and F2 (fig. 242).
		Switch defective	Check switch S2.
2	500 volts, 250 volts, −75 volts, −25 volts dc, and 6.3 volts ac missing; only 12 volts dc normal.	Transformer T4 primary defective.	Check transformer T4 resistance (par. 373).
3	500 volts, 250 volts, −75 volts, and −25 volts dc missing; 12 volts dc and 6.3 volts ac normal.	Open fuse	Check fuse F4.
		Tube defective	Check V4.
		Capacitor C5 shorted	Check C5 (fig. 243) for leakage.
		Filter reactor L4 open	Measure L4 resistance (par. 373).
		Transformer T4 secondary defective.	Measure T4 resistance.
4	500 volts, 250 volts, and 12 volts dc missing; 6.3 volts ac, −75 volts and −25 volts dc normal.	Filter capacitor shorted	Check capacitor C7.
		Rectifier D1 defective	Check D1.
		Resistor R9 defective	Check R9.
		Transformer T2 defective	Check transformer T2.
		Carrier control relay S5 winding shorted.	Check resistance of S5 winding coil (fig. 242).
5	500 volts, 250 volts, and −25 volts dc missing; 12 volts dc and 6.3 volts ac normal; −75 volts dc normal or above normal. (Wait 24 to 36 seconds for thermal relay to close.)	Resistor open	Check resistors R3, R4, and R5.
6	500 volts and 250 volts dc missing; 12 volts dc and 6.3 volts ac normal; −75 volts and −25 volts dc below normal.	Capacitor leaky	Check C5 and C6 for leakage.
7	500 volts and 250 volts dc missing; −75 volts, −25 volts, 12 volts dc, and 6.3 volts ac normal.	Interlock S1 defective	Check S1. Be sure interlock jumper plug is in place.
		Bias control S4 defective	Check contact adjustment of S4 (fig. 242).
		Thermal relay S3 not functioning	Check S3 by substitution.
8	250 volts dc missing; all others normal.	Fuse F3 open	Check fuse F3.
		Tube V3 defective	Check V3.
		Transformer T3 defective	Check T3 resistances (par. 373).
		Transformer T2 defective	Measure T2 resistances.
		Filter reactor L3 open	Measure L3 resistance.
		Defective relay	Check adjustment of S4 contacts (fig. 242).
9	500 volts dc missing; all others normal.	Fuse F5 open	Check fuse F5. (Look for shorts.)
		Tubes V1 and V2 defective	Test V1 and V2.
		Transformer T1 or T2 defective	Make voltage and resistance measurements at V1 and V2 (fig. 189). Measure T1 and T2 resistance.
		Filter reactor open	Measure resistance of L1 and L2.
10	500 volts and 250 volts dc missing; 12 volts dc low; −75 volts and −25 volts dc and 6.3 volts ac normal.	Filter capacitor C7 leaky	Check capacitor C7 leakage.
		Rectifier D1 defective	Check D1.
11	250 volts dc low; others normal	Filter capacitor leaky	Check C3 and C4 for leakage.
		Transformer T3 defective	Make voltage and resistance measurements at V3. Measure T3 resistance.
12	500 volts dc low; others normal	Filter capacitor leaky	Check C2 and C3 for leakage.
13	Excessive ripple voltage on 500-volt output.	Filter reactor shorted	Measure L1 and L2 resistance.
		Filter capacitor open	Measure C1 and C2 capacity.
14	Excessive ripple voltage on 250-volt output.	Filter reactor L3 shorted	Measure L3 resistance.
		Filter capacitor open	Measure C3 and C4 capacity.
15	6.3 volts ac missing; all others normal	Transformer T4 defective	Measure T4 resistances.

372. Voltage and Resistance Measurements

Voltage and resistance measurements for the PP–1331/FRN–20 are shown in figure 189, contained in separate envelope. Data on measurement procedures are also given in figure 189.

373. Transformer and Reactor Resistance Data

a. The following chart lists the dc resistances of transformer and reactor windings. Measurements of these resistances are made with the transformer or reactor removed from the circuit, either by disconnecting leads or by removing tubes or relay S4 from its socket.

b. In making resistance measurements of transformer or reactor windings, remember that the shorting of a small number of turns is not likely to show in resistance measurements. However, the presence of shorted turns will be indicated by abnormal heating of the reactor or transformer when in service or under prolonged use at the test bench.

Transformer or reactor	Connection points	Resistance (ohms)
L1	Across terminals	60.
L2	Across terminals	60.
L3	Across terminals	130.
L4	Across terminals	130.
T1	1–3	Less than 1.
	5–7	Less than 1.
	9–10	18.
	9–11	35.
	10–11	17.
T2	1–3	1.45.
	5–7	1.55.
	9–10	Less than 1.
	11–13	Less than 1.
	17–18	Less than 1.
	18–19	Less than 1.
T3	1–3	5.
	5–7	5.5.
	9–10	37.
	9–11	64.
T4	1–3	5.
	5–7	5.5.
	9–10	Less than 1.
	11–12	Less than 1.
	13–14	75.
	13–15	150.

Section XVIII. POWER SUPPLY PP–1415/FRN–22 TROUBLESHOOTING

***Warning:* Parts of this circuit are energized by high voltages when the power supply is in operation. Avoid physical contact with exposed parts or terminals.**

374. General

a. Power Supply PP–1415/FRN–22 supplies —12 volts dc at 3.5 amperes to the C–1738/FRN–20, and through it to other control circuits, for energizing relays.

b. The PP–1415/FRN–22 can be serviced in the cabinet, but removal to the test bench is recommended for safety and convenience. Service to this unit will require shutdown of the omnirange station. If a working unit is available for substitution, shutdown will not be necessary; however, permission to make the substitution must be obtained from the Officer in Charge.

375. Troubleshooting Reference Data

The following list of illustrations on chart will be useful in troubleshooting the PP–1415/FRN–22.

Fig No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
245	Power Supply PP–1415/FRN–22, rear view.
244	Power Supply PP–1415/FRN–22, interior view.
131	Power Supply PP–1415/FRN–22, schematic diagram.
190	Power Supply PP–1415/FRN–22, bench test setup.
191	Power Supply PP–1415/FRN–22, voltage and resistance diagram.
310	Power Supply PP–1415/FRN–22, wiring diagram.

376. Equipment Required

a. Test Equipment. Multimeter ME–77/U, TM 11–6625–203–12, is the only test equipment required for troubleshooting the PP–1415/FRN–22.

b. Additional Equipment. The additional equipment required to troubleshoot the PP–1415/FRN–22 is listed below with its common name.

Qty	Description	Common name
1	5-ohm 75-watt wire-wound resistor.	Load resistor.
1	Power cable (use W12 cable assembly supplied with unit).	Power cable.
1	Tool Equipment TE–113----------	Toolkit.

377. Removal and Reinstallation

a. Removal. To remove the PP–1415/FRN–22 for bench test servicing, disconnect the wiring harness from terminal board TB1202 (fig. 245), making sure of identification of wires for reconnection (fig. 16), and remove plug P829 from receptacle J1201. Remove the cabinet trim strips and chassis mounting screws and withdraw the PP–1415/FRN–22 from the cabinet.

b. Reinstallation. To reinstall the PP–1415/FRN–22, slide it into the cabinet opening and replace the chassis mounting screws and cabinet trim strips. Refer to figure 16 and reconnect the wiring harness to terminal board TB1201 and plug P829 to receptacle J1201.

378. General Precautions

a. When servicing the PP–1415/FRN–22 in the cabinet, energize the circuit by closing main circuit breaker K1001 and circuit breaker K1003.

b. Before proceeding with troubleshooting, make a visual inspection and correct the defects.

c. Do not apply power until such faults are corrected. Do not apply power if it will cause damage to this unit.

d. When a part has been found defective, check associated parts which may have failed as a result of the defect.

379. Bench Test Setup

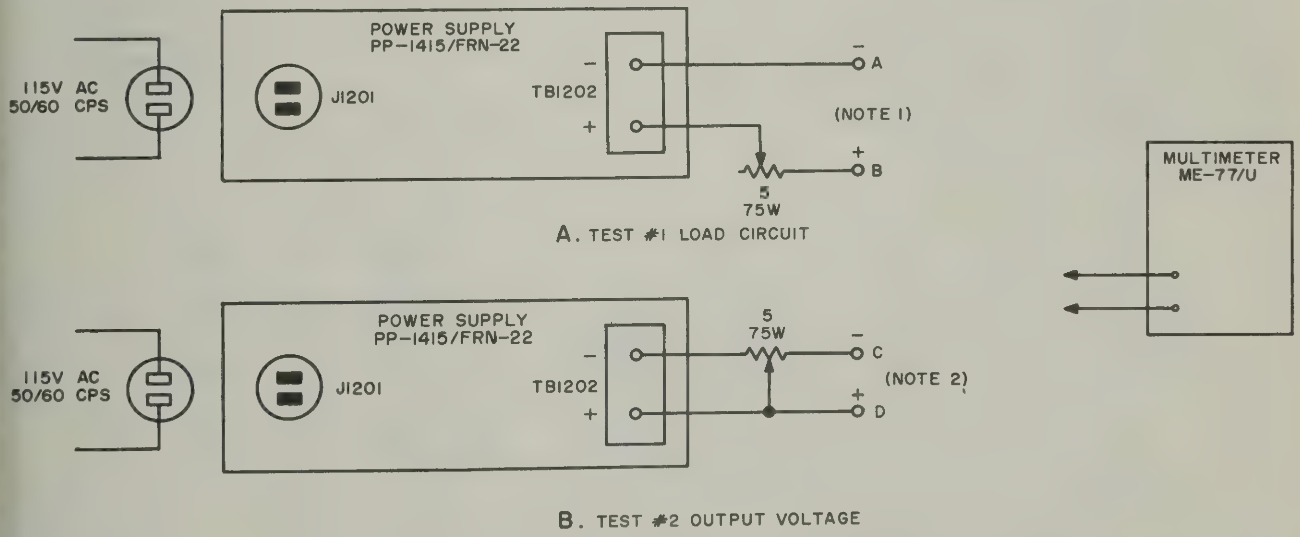
a. Connections for bench testing are shown in figure 190.

b. A 115-volt, 50- or 60-cps ac power source is required for bench testing. This power source should be provided with adequate switching to control the application of power.

c. Make the following connections:

(1) Use power cable assembly W12 (fig. 16), supplied with the equipment, for the power connection.

(2) Connect the 5-ohm 75-watt load resistor between the two terminals of TB1202.



A. TEST #1 LOAD CIRCUIT

B. TEST #2 OUTPUT VOLTAGE

NOTES

1. USE MULTIMETER ME-77/U FOR LOAD CURRENT MEASUREMENT.
   TEST #1 RANGE 10 AMP DC.
   MEASURE BETWEEN TEST POINTS A AND B POLARITY AS INDICATED.
2. USE MULTIMETER ME-77/U FOR OUTPUT VOLTAGE.
   TEST #2 RANGE 50V DC.
   MEASURE BETWEEN TEST POINTS C AND D POLARITY AS INDICATED.

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Figure 190. Power Supply PP–1415/FRN–22, bench test setup.

380. Localizing Troubles

a. Preliminary Operational Check. Before proceeding with bench tests, make an operational test of the PP–1415/FRN–22 by applying power and looking for signs of overload such as fuses blowing, smoke, overheating, sounds or smells.

b. Use of Chart. To troubleshoot the 12-volt power supply by procedures given in the troubleshooting chart, make bench test measurements as indicated in figure 190, for starting indications of the trouble source. These indications, with their probable source, are listed in the chart with the necessary procedures for locating the defect.

c. Troubleshooting Chart.

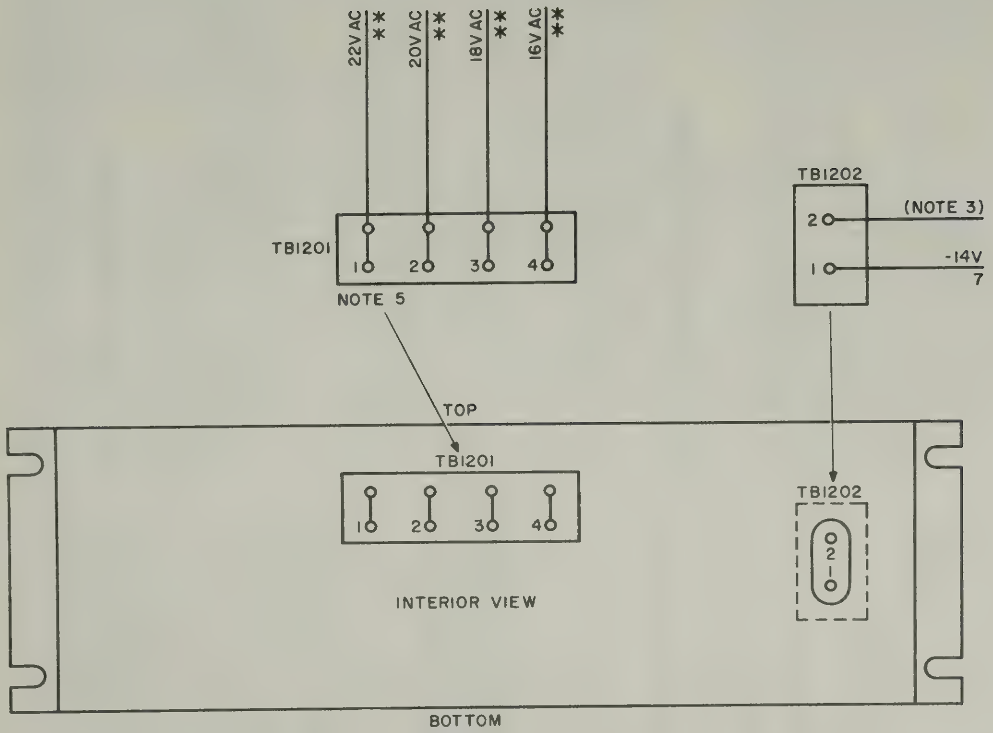
Item	Indication	Probable trouble	Procedure
1	No output voltage	Open fuse	Check fuse F1201 and F1202 (fig. 245).
		Rectifier defective	Check rectifier CR1201.
		Transformer defective	Check T1201 resistance (par. 381*b*).
2	Output voltage low	Rectifier defective	Check rectifier CR1201.
		Defective transformer	Check T1201 resistance.
		Capacitor leaky	Check C1201 and C1202 for leakage.
3	Fuse F1201 blows repeatedly	Transformer T1201 defective (turns shorted).	Check transformer T1201 for overheating (resistance measurements not likely to reveal this condition).
		Rectifier CR1201 has shorted section.	Check CR1201.
		Filter capacitor shorted	Check C1201 and C1202.

381. Isolating Trouble

a. Voltage and Resistance Measurements. The voltage and resistance diagram of the PP–1415/FRN–22 is shown in figure 191, which includes notes on measurements procedures.

b. Transformer Resistance. The dc resistances of the transformer windings are given in the following chart. The transformer must be completely isolated from other components before making resistance measurements.

Transformer	Connection points	Resistance (ohms)
T1201	1–2	1.6.
	3–4	1.9.
	5–6	Less than 1.
	5–7	Less than 1
	5–8	Less than 1.
	5–9	Less than 1.



NOTES

1. VOLTAGE MEASUREMENTS MADE WITH POWER SUPPLY PP-1415/FRN-22 IN OPERATION, EITHER AS PART OF OMNIRANGE SET OR ON TEST BENCH.
2. RESISTANCE MEASUREMENTS MADE WITH ALL EXTERNAL CABLES AND WIRING DISCONNECTED.
3. DC VOLTAGE AND RESISTANCE AT TERMINAL BOARD TB1202 IS MEASURED AT TERMINAL 1, WITH REFERENCE TO TERMINAL 2; WITH A 20,000 OHMS-PER-VOLT METER.
4. AC VOLTAGE MEASURED AT TB1201 WITH REFERENCE TO TERMINAL 5 OF TRANSFORMER T1201 WITH 1,000 OHMS-PER-VOLT METER.
5. RESISTANCES AT TERMINAL BOARD TB1201 MEASURED WITH REFERENCE TO TERMINAL 5 OF TRANSFORMER T1201, USING A 20,000 OHMS-PER-VOLT METER. ** ALL RESISTANCE ON TERMINAL BOARD TB1201 ARE LESS THAN ONE OHM.
6. VOLTAGES ABOVE THE LINE, RESISTANCES BELOW THE LINE.

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Figure 191. Power Supply PP-1415/FRN-22, voltage and resistance diagram.

***Warning:* The remote control unit contains selenium rectifiers which give off poisonous fumes when they burn or arc. *Do not inhale these fumes.* Remove power immediately and ventilate the shelter. Do not attempt to handle rectifiers until they have cooled.**

382. General

a. The remote control unit is used to control both transmitting equipments. By means of dial impulses, it selects the circuits and equipment to be activated.

b. The remote control unit may be serviced in place in the remote control cabinet but removal to the test bench for troubleshooting is safer and more convenient.

383. Troubleshooting Reference Data

The following list of illustrations will be useful during troubleshooting.

Fig. No.	Caption
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
132	Remote dial and audio signal circuits, schematic diagram.
133	Indicator circuits, schematic diagram.
286	Radio Set Control C–1739/FRN–20, schematic diagram.
192	Radio Set Control C–1739/FRN–20, bench test setup.
222	Radio Set Control C–1739/FRN–20, top view.
223	Relay adjustment data.
224	Dial adjustment data.
311	Radio Set Control C–1739/FRN–20, wiring diagram.

384. Equipment Required

a. Test Equipment. Test equipment required for troubleshooting the remote control unit is listed below with the applicable technical manual and common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.

b. Additional Equipment. Additional equipment required to troubleshoot the remote control unit is listed in following column with a common name assigned to each.

Quantity	Description	Common name
1	500-ohm 1-watt resistor	Limiting resistor.
1	Ac power cable (use W22, furnished).	Power cable.
1	12-volt dc, 1-ampere power source.	Dc power supply.

385. Removal and Reinstallation

a. Removal. To remove the remote control unit for bench tests, disconnect the microphone and handset. Disconnect power cable W22 and the connections at terminal board E501 (fig. 16). Remove the chassis mounting screws and withdraw the remote control unit from the cabinet.

b. Reinstallation. To reinstall the remote control unit, slide it into the cabinet opening and replace the mounting screws. Reconnect power cable W22, the connections at terminal board E501, the microphone, and the handset.

***Caution:* Do not connect power cable W22 to the ac power source unless *all* units of the remote control cabinet are to be returned to service.**

386. General Precautions

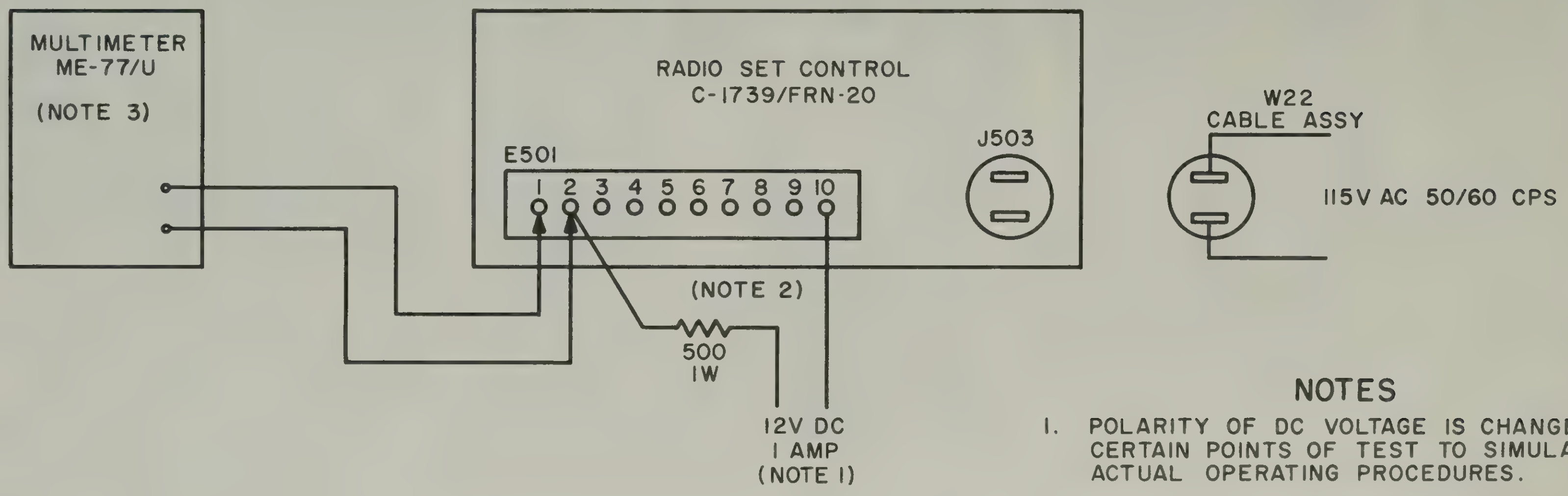
a. With the remote control unit disconnected from all power sources and external wiring, make the following resistance checks with the multimeter.

Measure between points	Resistance (ohms)
Either pin of J503 (fig. 222) and chassis ground.	Infinite.
Terminal 5 of T502 and chassis ground	Infinite.

b. If a low resistance reading is obtained, check transformer T502. Use the resistance values given in paragraph 389*b*. Correct the trouble before applying power.

387. Bench Test Setup

a. Bench test setup for remote control unit troubleshooting is shown in figure 192.



NOTES

1. POLARITY OF DC VOLTAGE IS CHANGED AT CERTAIN POINTS OF TEST TO SIMULATE ACTUAL OPERATING PROCEDURES.
2. USE #20 AWG STRANDED WIRE FOR VOLTAGE CONNECTION TO 12V SUPPLY.
3. MULTIMETER SET TO 250V AC RANGE.

TM215-237

Figure 192. Radio Set Control C-1739/FRN-20, bench test setup.

b. Power sources required are 115 volts ac at 50 or 60 cps and 12 volts dc at 1 ampere, with adequate switching to control their application.

***Caution:* Do not use dial I 501 when the 12-volt dc voltage is applied.**

388. Localizing Trouble

a. General. The remote control unit is divided into three circuit groups for troubleshooting; the power supply and dial, audio and intercommunicating circuits, and alarm circuits. Localization is achieved by performing the following operational check and comparing results with indications given in the troubleshooting chart.

b. Operational Check. With bench test connections made as shown in figure 192, perform the following steps and note the results:

(1) Apply 115-volt power, and leave the 12-volt dc power turned off.

(2) Cock dial I 501; that is, dial a number and do not release the dial. The multimeter should indicate 115 volts ac.

(3) Allow the dial to return to its home position; the multimeter needle should fluctuate.

(4) Cock the dial again, and momentarily ground pin 4 of J502 (fig. 222) to the chassis; this energizes relay O 501. The multimeter needle should drop to zero when O 501 energizes.

(5) Release the dial and disconnect the multimeter.

(6) Connect the 12-volt dc power, negative to terminal 10 and positive to terminal 2 of E501, which is the equivalent of dialing No. 9 or 7 in the normal operating procedure.

(7) Move the ALARM SELECTOR switch to each of its three positions and note the operation of the indicator lamps and buzzer.

(8) Reverse the polarity of the 12 volts dc, the equivalent of dialing No. 8 or 6 in the normal operating procedure.

(9) Move the ALARM SELECTOR switch through its three positions again, and note the operation of the indicator lamps and buzzer.

c. Use of Chart. After completing the operational check, consult the *Indication* column of the chart for conditions encountered. The *Probable trouble* column will indicate the defective circuit group and the *Procedure* column will suggest means of isolating trouble to the defective part or circuit portion.

d. Troubleshooting Chart.

Item	Identification	Probable trouble	Procedure
1	No output with 115 volts ac applied and the dial cocked (step 2 of operational check).	Blown fuse	Check F501 (fig. 222).
		Defective power cable	Check W22 fittings (fig. 16) and continuity.
		Defective dial sticking contacts	Check dial contacts (fig. 224).
		Transformer defective	Check T501 and T502 windings (par. 389*b*).
2	Multimeter needle does not fluctuate when dial is released.	Defective dial	Check dial contacts.
3	Relay O 501 does not close when terminal 4 of J502 is grounded (step 4 of operational check).	Relay O 501 defective	Check O 501 winding resistance (fig. 223).
4	I 503 does not light with S501 in down position and 115 volts ac and +12 volts dc applied.	Bulb burned out	Check I 503 (fig. 222).
		Defective switch S501	Check S501 contacts (ch. 5).
		Defective rectifier CR502	Replace rectifier CR502.
		Defective relay O 502	Check O 502 coil resistance and contact adjustment (fig. 223).
5	Same as step 4 above, but buzzer I 502 does not sound.	Defective buzzer I 502	Check I 502 coil resistance (par. 389*b*).
		Defective switch S501	Check S501 contacts (ch. 5).
6	Same as step 4 above, but move S501 to center position and buzzer is silent.	Defective switch S501	Check S501 contacts.
7	Move S501 to upper position, buzzer I 502 does not sound and I 503 does not go out.	Relay contacts sticking	Check relay O 502 contacts (fig. 223).
		Defective switch	Check switch S501.
		Shorted rectifier	Replace CR501.

Item	Identification	Probable trouble	Procedure
8	Connect equipment as in step 8 of operational check and place S501 in down position; buzzer I 502 does not sound and lamp I 503 does not light. Move S501 to upper position and I 504 does not light.	Defective rectifier Defective relay Defective lamp Defective switch	Check CR501. Check coil and contacts of relay O 502 (fig. 223). Replace lamp I 504. Check contacts of S501.

389. Isolating Trouble

a. Troubleshooting audio circuits in the remote control unit is accomplished by a continuity check of the straight-through wiring (fig. 286). This procedure requires no power.

b. Additional procedures for isolating trouble in the remote control unit consist of measuring resistances of the transformer and buzzer windings. These resistance values are given in the adjoining chart.

390. Final Testing

After troubleshooting the remote control unit, and before returning it to the cabinet, rerun the operational check (par. 388*b*). A good operational check usually is sufficient.

Transformer or buzzer	Connection points	Resistance (ohms)
I 502 (fig. 222)	Across leads	6.
T 501	1–4	53.
	3–6	53.
	A–D	44.
	A–F	88.
T 502	1–2	43.
	3–4	49.
	5–6	150.
	7–8	Less than 1.

Section XX. RADIO SET CONTROL C–1738/FRN–20 TROUBLESHOOTING

***Warning:* The C–1738/FRN–20 contains selenium rectifiers which release poisonous fumes if they burn or arc. *Do not inhale these fumes.* Remove power immediately, ventilate, and do not attempt to handle the rectifiers until they have cooled.**

391. General

a. The C–1738/FRN–20 is used to control both transmitting equipments, by means of dial pulses, selecting circuits and equipment to be activated.

b. Although the C–1738/FRN–20 may be serviced in the CY–1738/FRN–20 cabinet, removal to the test bench for troubleshooting is safer and more convenient.

392. Troubleshooting Reference Data

The following list of illustrations on chart will be useful in troubleshooting.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
44	Radio Set Control C–1738/FRN–20, front panel removed.
288	Radio Set Control C–1738/FRN–20, schematic diagram.
155	Control circuits, schematic diagram.
193	Radio Set Control C–1738/FRN–20, bench test setup.
224	Telephone dial parts identification.
246	Radio Set Control C–1738/FRN–20, top view.
247	Radio Set Control C–1738/FRN–20, rear view.
248	Relay adjustment data.
249	Minor switch adjustment data.
312	Radio Set Control C–1738/FRN–20, wiring diagram.

393. Equipment Required

a. Test Equipment. Test equipment required for troubleshooting is listed below with the applicable technical manual and assigned common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.

b. Additional Equipment. The additional equipment required for troubleshooting is listed below with the assigned common name.

Qty	Description	Common name
1	300-ohm, 1-watt resistor	Limiting resistor.
1	12-volt, 1-ampere dc supply	12-volt supply.
1	Female plug, H. B. Jones Co. part No. P 333 FHT.	Test plug.
1	Ac supply of 70 to 80 volts at 50 or 60 cps.	Ac supply.

394. Removal and Reinstallation

a. Removal. To remove the C–1738/FRN–20 from the CY–1897/FRN–22 disconnect the power plugs, the handset from J202, and the telephone line from E201. Remove the cabinet trim strips and the chassis mounting screws, and withdraw the C–1738/FRN–20 from the cabinet.

b. Reinstallation. To reinstall the C–1738/FRN–20 place it in the cabinet opening and replace the chassis mounting screws and cabinet trim strips. Reconnect the handset to J202, the telephone line to E201, and the power plugs.

c. Access to Relays. Remove the dust cover by removing the two thumbscrews that hold the dust cover to the rear of the chassis. Access to the chassis interior can be gained by removing the seven sheet metal screws that hold the top cover. The front panel may also be removed partially by loosening the knurled captive thumbscrews at each end of the panel.

395. General Precautions

a. RING-TALK switch S201 is a spring-return switch, and will automatically be properly set for troubleshooting. Set the switch in the center position.

b. Make a thorough visual inspection before initiating other troubleshooting procedures.

c. Make a short-circuit test with the multimeter resistance scale between the following points and chassis. No power is to be applied.

Measurement points	Resistance (ohms)
Either terminal of E201 (fig. 16) (close O 202 manually).	Infinite.
Terminal 6 of J205	Infinite.
Terminal 7 of J205	Infinite.
Terminal 19 of J205	Infinite.
Terminal 20 of J205	Infinite.
Terminal 29 of J205	Infinite.
Terminal 31 of J205	Infinite.

396. Bench Test Setup

a. Bench test connections are shown in figure 193.

b. Power source requirements are 70 to 80 volts ac at 50 or 60 cps, and 12 volts dc at 1 ampere, with adequate switching to control power application.

c. Make up the test plug as shown in B, and leave the plug cover off to provide access to the test points. Use H. B. Jones Co. part No. P 333 FHT (same as P804 in fig. 16) obtained from bulk or spare supplies. Make the following connections.

Terminals	Connections
8	Jumper to terminals 16 and 30. (All wire connections are made with #20 AWG.)
3, 4, 7, 17, 18, 21, 26, and 30.	Attach individual test points of stiff, bare wire 2 inches long.
6	3-foot length of wire.
19	Jumper to terminal 20.
28	Jumper to terminal 29.
31	3-foot length.
33	3-foot length.

397. Localizing Trouble
(fig. 247)

a. General. For troubleshooting purposes, the C–1738/FRN–20 is divided into three main circuits.

(1) The remote control and ac supply circuits.

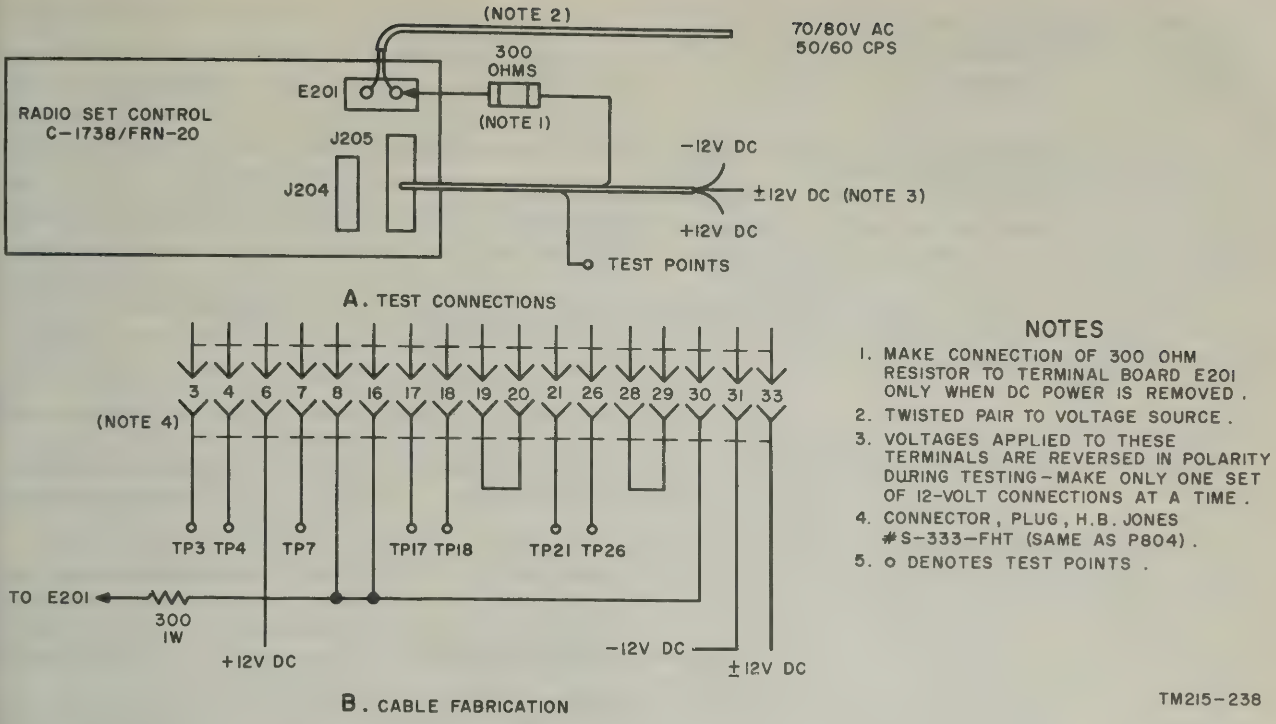
(2) The local dialing and control circuits.

(3) The audio and signaling circuits.

b. Operational Check. Test the three circuits by following the steps of the operational check in *c* below. As each step is performed, note the results.

(1) Connect the multimeter (set on the 50-volt dc scale) to the output of rectifier CR201 (fig. 246). Apply 70 to 80 volts ac across terminal board E201. The multimeter should indicate 10 to 14 volts dc.

(2) Remove the ac connections and connect the multimeter between one terminal of E201 (fig. 247) and the chassis. Connect a 300-ohm limiting resistor from the other terminal of E201 to the chassis. Apply 12 volts dc to terminal 6 (positive) and terminal 33 (negative) of



NOTES

1. MAKE CONNECTION OF 300 OHM RESISTOR TO TERMINAL BOARD E201 ONLY WHEN DC POWER IS REMOVED.
2. TWISTED PAIR TO VOLTAGE SOURCE.
3. VOLTAGES APPLIED TO THESE TERMINALS ARE REVERSED IN POLARITY DURING TESTING—MAKE ONLY ONE SET OF 12-VOLT CONNECTIONS AT A TIME.
4. CONNECTOR, PLUG, H.B. JONES #S-333-FHT (SAME AS P804).
5. o DENOTES TEST POINTS.

Figure 193. Radio Set Control C1738/FRN-20, bench test setup.

J205. Multimeter indication should be 4 to 6 volts dc. Relay O 207 should energize.

(3) Leave the multimeter and limiting resistor connected as in (2) above. Connect the 12-volt dc supply to terminal 31 (—12 volts) and terminal 33 (+12 volts) of J205. Set the multimeter for REV DC reading. The voltage indication should be —4 to —6 volts, and —12 volts should be available at terminals 19 and 26, referenced to chassis.

(4) Disconnect the multimeter, leave the limiting resistor in place, and leave the 12-volt connections as in (3) above. Cock dial I 201, energizing O 201 and O 202 and moving arm of K201 to the home position.

(5) Release the dial. The K201 arm should move to a position corresponding to the number dialed. When the K201 arm comes to rest, O 201 and O 202 will deenergize.

(6) Dial No. 9. Relay O 204 should energize and ground terminal 21 of J205, placing —12 volts on terminal 1. Terminal 9 of J204 should also show —12 volts to chassis.

(7) Dial No. 8 Relays O 205, O 206, and O 207 should energize, I 202 should light, and relay O 204 should remain closed. Terminals 1, 2, 3, 7, and 17 of J205 should show —12 volts dc to chassis and terminal 4 of J205 should be grounded to chassis, and —12 volts should be available between terminal 8 of J204 and chassis.

(8) Dial No. 5 (or 3 or 4) to remove the direct connection of —12 volts dc from K201 arm and O 205; O 205 should remain energized, with holding voltage supplied by O 206. There should be —12 volts dc available between the terminal of J204 that corresponds to the number dialed and the chassis.

(9) Dial No. 10. Relay O 203 should energize, removing —12 volts from terminal 19 of J205, and deenergizing O 204 and O 206. Deenergizing O 206 should deenergize O 205 and I 202. As soon as O 204 opens, O 203 should also deenergize. A —12 volts dc to chassis should be available at terminal 10 of J204.

(10) Dialing No. 7 and 6 should put —12 volts dc on terminals 7 and 6, respectively, of J204.

c. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	With ac at E201 (fig. 16), dc output of CR201 is not 10 to 14 volts.	Resistor R201 defective or misadjusted.	Check R201 (fig. 246) resistance and adjustment.
		Rectifier CR201 defective	Replace CR201.
2	With +12 volts on terminal 6 of J205, output at E201 is not 4 to 6 volts.	Resistor R204 defective	Check R204 resistance.
		Relay O 206 contacts defective	Check O 206 contacts (fig. 248).
3	With −12 volts on terminal 31 of J205, and O 206 manually closed, output at E201 is not −4 to −6 volts dc.	Resistor R205 defective	Check R205 resistance.
		Relay O 206 contacts defective	Check O 206 contacts (fig. 248).
		Relay O 207 defective	Check O 207 coil resistance (fig. 248).
		Switch S201 contacts defective	Check S201 contacts (chapter 5).
		Transformer T201 defective	Check T201 winding resistances (par. 398*b*).
4	With dial I 201 cocked, arm of K201 does not set on home position.	Dial contacts defective	Check dial contacts (fig. 224).
		Relay O 202 defective	Check O 202 coil resistance (fig. 248). Check O 202 contact adjustment (fig. 248).
		Off-normal contacts of K201 defective.	Check K201 off-normal contacts (fig. 249).
		Relay O 201 defective	Check O 201 coil resistance (fig. 248). Check O 201 contact adjustment (fig. 248).
		Minor switch K201 release coil defective.	Check K201 release coil resistance (fig. 249).
5	When dial is released, minor switch K201 arm does not move to contact corresponding to number dialed.	Dial I 201 contacts defective	Check I 201 contacts (fig. 224).
		Minor switch K201 step coil defective.	Check K201 step coil resistance (fig. 249).
		C201 shorted (K201 will not step)	Check C201 capacitance.
6	When 9 is dialed, O 204 does not close	Relay O 204 defective	Check O 204 coil resistance (fig. 248).
		Relay O 201 contacts defective	Check O 201 contact adjustment (fig. 248).
		Minor switch K201 does not reach contact 9.	Check dial contacts (fig. 224). Check K201 step coil (fig. 249).
7	When 8 is dialed, indicator I 202 does not light.	Bulb I 202 defective	Check bulb I 202.
	Relay O 205 does not close	Relay O 205 defective	Check O 205 coil resistance (fig. 248).
		Minor switch K201 arm not on contact 8.	Check dial contacts (fig. 224). Check K201 step coil (fig. 263).
	Relay O 204 does not hold	Relay O 204 contacts defective	Check O 204 contact adjustment (fig. 248).
	Relay O 206 does not close	Relay O 206 defective	Check O 206 coil resistance (fig. 248).
		Relay O 204 contacts defective	Check O 204 contact adjustment (fig. 248).
		Relay O 205 contacts defective	Check O 205 contact adjustment (fig. 248).
	Relay O 207 does not close	Relay O 206 contacts defective	Check O 206 contacts (fig. 248).
8	When 5 (or 3 or 4) is dialed relay O 205 does not hold.	Relay O 206 contacts defective	Check O 206 contact adjustment (fig. 248).
9	When 10 is dialed relay O 203 does not close.	Relay O 204 contacts defective	Check O 204 contact adjustment (fig. 248).
		Minor switch K201 arm not on contact 10.	Check dial contacts (fig. 224). Check K201 step coil (fig. 249).
10	When 7 or 6 is dialed, minor switch K201 arm does not move to contact corresponding to number dialed.	Faulty dial contact	Check I 201 contacts (fig. 249).
		K201 step coil defective	Check K201 step coil (fig. 249).

398. Isolating Troubles

a. Continuity Checks. Troubleshooting the audio and signaling circuits is accomplished by continuity checks in the straight-through wiring of the component, once operational checks have been made. All external connections are removed for continuity checks. Relays may be left in normal positions for continuity checks, or they can be operated manually. Continuity checks should be made with reference to the schematic diagram (fig. 288).

b. Voltage and Resistance Measurements. Isolation techniques for troubleshooting the C-1738/FRN-20 include voltage measurements already listed in the operational check, and resistance measurements of the relay windings (chapter 5).

399. Additional Troubleshooting Data

Resistance measurements of transformer T201 are given in the following table.

Transformer	Connection points	Resistance (ohms)
T201	1–4	53
	3–6	53
	A–D	44
	C–F	44

Section XXI. RADIO SET TRANSFER CONTROL C–1840/FRN–22 TROUBLESHOOTING

400. General

a. The C–1840/FRN–22, when activated by an equipment failure or power interruption, will automatically seek to restore a normal navigational signal on the air. It will first try to put equipment No. 1 on the air and then equipment No. 2, cycling between the two equipments three times, if necessary, and then shutting down the omnirange station if restoration is impossible.

b. The C–1840/FRN–22 may be serviced in its regular operating position but it is safer and more convenient to troubleshoot it on the test bench.

401. Troubleshooting Reference Data

The following list of illustrations on chart will be helpful in troubleshooting the C–1840/FRN–22.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
28	Radio Set Transfer Control C–1840/FRN–22, thermal relay and fuse locations.
141	Radio Set Transfer Control C–1840/FRN–22, schematic diagram.
194	Radio Set Transfer Control C–1840/FRN–22, bench test setup.
250	Radio Set Transfer Control C–1840/FRN–22, interior view.
251	Radio Set Transfer Control C–1840/FRN–22, rear view.
252	Radio Set Transfer Control C–1840/FRN–22, sequence timer repair and replacement.
253	Radio Set Transfer Control C–1840/FRN–22, sequence timer adjustment plate.
254	Relay adjustment data.
255	Relay adjustment data.
256	Minor switch adjustment data.
313	Radio Set Transfer Control C–1840/FRN–22, wiring diagram.

402. Equipment Required

a. Test Equipment. The test equipment required is listed below with the applicable technical manual and assigned common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12	Multimeter.

b. Additional Equipment. Additional equipment required is listed below.

Qty	Description	Common name
1	18-contact female plug H. B. Jones Co. part No. S 318 FHT, similar to P801.	Test plug.
2	Small alligator clip (type not critical).	Alligator clip.
1	Power input cable (fabrication in par. 405c).	Power cable.
1	Stopwatch (type not critical)	Stopwatch.
1	12-volt, 1-ampere dc power supply.	12-volt supply.

403. Removal and Reinstallation

a. Removal. To remove the C–1840/FRN–22 for troubleshooting, remove plugs P801 and P819 from receptacles J602 and J601, respectively. Remove the cabinet trim strips and chassis mounting screws. Withdraw the chassis from the cabinet.

b. Reinstallation. To reinstall the C–1840/FRN–22 after troubleshooting, replace it in the cabinet, replace the chassis mounting screws and cabinet trim strips, and return plugs P801 and P819 to receptacles J602 and J601, respectively.

c. Access to Unit Interior. Access to the chassis interior is gained by loosening two knurled thumbscrews at the panel ends and removing the front panel. Access to relays on rear of chassis is gained by removing the dust cover, held by two screws.

404. General Precautions

a. Before initiating other troubleshooting procedures, make a thorough visual inspection.

b. When the test plug is in place, use care to avoid accidental contact of clip leads to chassis or to each other.

c. Make a quick short-circuit check with the multimeter at the following points.

Measure from	To	Resistance (ohms)
Terminal 1 of J602	Terminal 18 of J602	Infinite.
Terminal 11 of J602	Terminal 18 of J602	Infinite.
Terminal 16 of J602	Terminal 18 of J602	Infinite.

405. Bench Test Setup

a. Connections for bench testing are given in figure 194.

b. Voltage sources required for bench tests are:

(1) 115 volts ac at 50 or 60 cycles, with adequate switching to control power application.

(2) 12 volts dc at 1 ampere, with adequate switching to control power application.

c. Make up the following test connections and cables:

(1) A power cable of two #18 AWG wires with a male two-terminal plug at one end and female plug (General Electric No. 4317-1), similar to plug P819, at the other end. Plugs can be obtained from bulk or spare supplies.

(2) Use an 18-terminal female plug similar to P801 (H. B. Jones Co. part No. S 318 FHT) obtained from bulk or spare supplies, and make test plug connections according to B, figure 239.

406. Localizing Trouble

a. General. Use of the above test setup permits operating the C-1840/FRN-22 in a manner simulating actual operation as part of the omnirange set. By this method, observation and measurement of sequence switching and voltage outputs during cycling, observation of relay action, and continuity checks of straight-through wiring furnish needed troubleshooting information.

b. Operational Check. The following operational check procedure will simulate normal operation. Note the results of each step. Because the transfer cycle is continuous and automatic, once

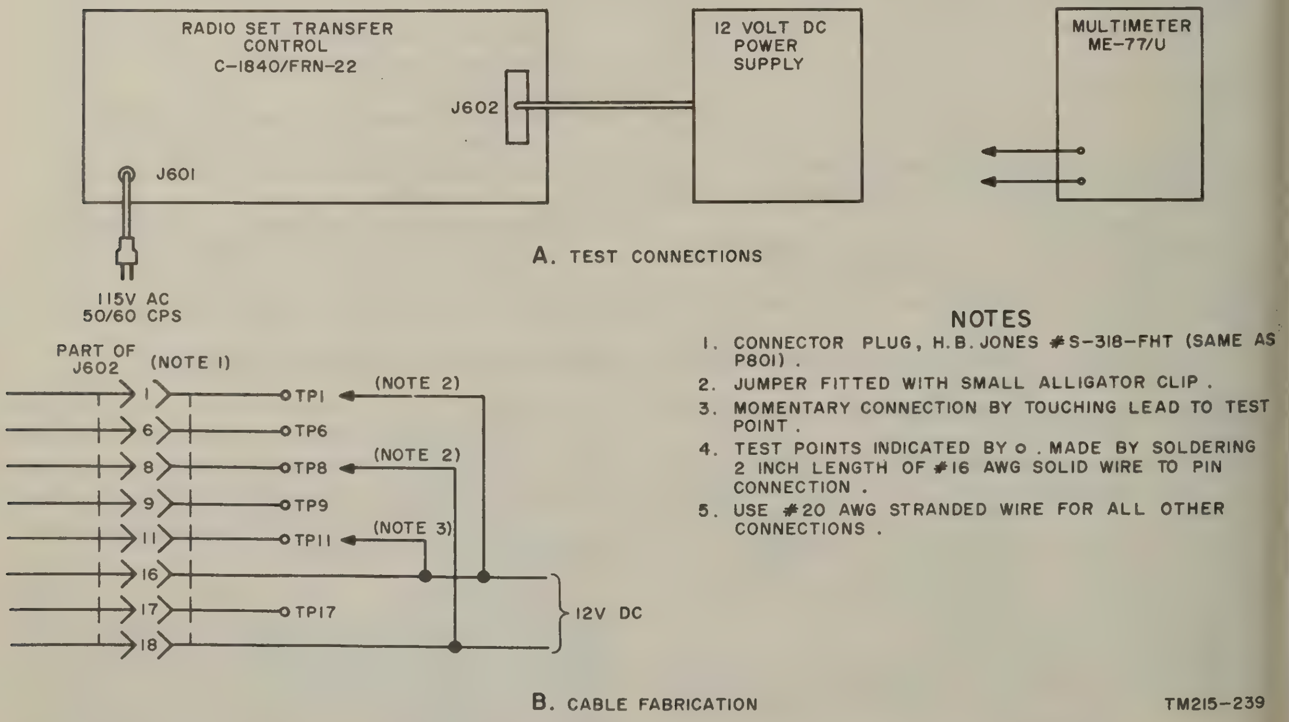

RADIO SET TRANSFER CONTROL C-1840/FRN-22
J602
J601
115V AC 50/60 CPS
12 VOLT DC POWER SUPPLY
MULTIMETER ME-77/U
A. TEST CONNECTIONS
PART OF J602
(NOTE 1)
1
6
8
9
11
16
17
18
TP1
TP6
TP8
TP9
TP11
TP17
(NOTE 2)
(NOTE 2)
(NOTE 3)
12V DC
NOTES
1. CONNECTOR PLUG, H.B. JONES #S-318-FHT (SAME AS P801).
2. JUMPER FITTED WITH SMALL ALLIGATOR CLIP.
3. MOMENTARY CONNECTION BY TOUCHING LEAD TO TEST POINT.
4. TEST POINTS INDICATED BY o. MADE BY SOLDERING 2 INCH LENGTH OF #16 AWG SOLID WIRE TO PIN CONNECTION.
5. USE #20 AWG STRANDED WIRE FOR ALL OTHER CONNECTIONS.
B. CABLE FABRICATION
TM215-239

Figure 194. Radio Set Transfer Control C-1840/FRN-22, bench test setup.

initiated, it may be necessary to run through the cycle twice, taking voltage measurements and observing relay action the first time, and timing the sequence switching operations on the second cycle. Follow this procedure:

(1) Clip the short lead from terminal 18 (fig. 194) to terminal 8 test point. Apply 115-volt ac power. Wait 20 seconds and then apply 12-volt dc power. Reading of —12 volts dc should appear at terminal 17 (referenced to terminal 18 or chassis).

(2) Touch the short lead from terminal 16 to terminal 11. Relay K601 (fig. 251) should energize at the moment of contact, unless minor switch K605 is off its home position. In this case, K605 will release to the home position when terminals 11 and 16 are jumpered, and relay K601 will energize after K605 homes. Be sure to maintain the jumper contact between terminals 11 and 16 long enough to allow this to take place.

(3) Clip the short lead from terminal 16 to terminal 1; this places the C–1840/FRN–22 in readiness for a simulated alarm.

(4) Remove the clip lead from terminal 8 to simulate an alarm. Reconnect the clip lead after the motor starts. Relay K601 deenergizes and relay K602 should energize, starting the timer motor of S601. Motor operation is best observed through the window in the end of the motor housing. Relay K602 removes —12 volts from terminal 17.

(5) When the motor starts, the first transfer cycle automatically runs to completion, following the sequence below. (Refer to figs. 252 and 253.)

  (*a*) Cam A closes S601A 6.6 seconds (if ac line frequency is 60 cps) after K602 energizes and the motor starts (7.9 seconds if frequency is 50 cps).

  (*b*) Cam B closes S601B 6.6 seconds (or 7.9 seconds) after S601A closes, placing —12 volts dc on terminal 9 of J602. (These terminal voltages are referenced to terminal 18 of chassis.)

  (*c*) Cam C actuates S601C 66.6 seconds (or 79.9 seconds) after S601B closes, energizing relay K603 and stepping minor switch K605 to contact No. 2. Terminal 11 has —12 volts dc, momentarily, before K605 steps.

  (*d*) Cam D actuates S601D 6.6 seconds (or 7.9 seconds) after S601C operates, energizing K604 and delivering —12 volts to terminal 6.

  (*e*) Cam B releases S601B 133.3 seconds (or 159.9 seconds) after S601D operates, deenergizing relays K602, K603, and K604, restoring —12 volts dc to terminal 17, and removing —12 volts dc from terminal 6.

  (*f*) Cam C releases S601C 6.6 seconds (or 7.9 seconds) after S601B has opened.

  (*g*) Cam D releases S601D 6.6 seconds (or 7.9 seconds) after S601C releases.

  (*h*) Cam A releases S601A 13.3 seconds (or 15.9 seconds) after S601D releases, deenergizing motor of S601.

(6) Energizing relay K601 prevents repetition of the transfer cycle. (After relay K602 deenergizes, it will immediately reenergize to continue motor operation for the second transfer cycle, if K601 is not energized.)

(7) When the motor stops after the transfer cycle ends, minor switch K605 (fig. 251) arm should be in position No. 2. Check the power failure reset by shutting off 115-volt ac power (leaving 12-volt dc on) for several seconds. This allows thermal relay K606 to close and applies —12 volts dc to minor switch K605 release coil and returns K605 arm to position No. 1, the home position.

c. Use of Chart. Noting the results of each step of foregoing operational check, departures from normal operation will become apparent. These departures are listed in the *Indication* column of the troubleshooting chart.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	−12 volts not present at terminal 17 of J602 when dc power is applied.	Relay K602 (fig. 251) defective	Check K602 contacts (fig. 254).
		Relay K603 (fig. 251) defective	Check K603 contacts (fig. 255).
2	Relay K601 operates improperly:		
	Energizes *before* terminals 11 and 16 are jumpered.	Relay K606 defective	Remove K606 from the socket and repeat the beginning steps of the operational check. If this corrects the trouble, replace K606.
		Relay K601 defective	Check K601 contacts (fig. 254).
	Does not energize when terminals 11 and 16 are jumpered (when terminal 8 is jumpered to terminal 18).	Relay K601 defective	Check K601 coil (fig. 254).
		Minor switch K605 defective:	
		Off-normal contacts, if arm in home position.	Check K605 off-normal contacts (fig. 256).
		Release coil, if arm is off home position.	Check K605 release mechanism (fig. 256).
	Energizes at moment of jumper contact between terminals 11 and 16, but does not hold.	Relay K601 defective	Check K601 contacts.
3	When normal signal condition (terminals 8 and 18 jumpered) exists, any part of transfer cycle is in operation (timer motor or K602).	Relay K602 defective	Check K602 contacts (fig. 251).
		Switch S601A defective	Check S601A contacts (fig. 252).
4	When alarm is simulated:		
	Relay K601 does not deenergize	Relay K601 defective	Check K601 contacts (fig. 254).
	Relay K602 does not energize, and motor of S601 does not operate.	Relay K601 defective	Check K601 contacts (fig. 254).
		Relay K603 defective	Check K603 contacts (fig. 255).
		Minor switch K605 defective	Check K605C arm (fig. 256).
		Relay K602 defective	Check K602 coil (fig. 254).
	Timer motor does not operate	Fuse F601 defective	Check fuse F601 (fig. 251).
		Relay K602 defective	Check K602 contacts (fig. 254).
	S601A does not operate properly, or at proper time.	Cam A plates not properly adjusted.	Check cam A plate setting (fig. 252).
			Check cam A positioning (fig. 252).
	S601B does not operate properly, or at proper time.	Cam B plates not properly adjusted.	Check cam B plate settings (fig. 252).
			Check cam B positioning (fig. 252).
	−12 volts dc not present at terminal 9 after S601B closes.	Switch S601B defective	Check switch S601B (fig. 252).
		Switch S601C defective	Check switch S601C (fig. 252).
		Minor switch K605A defective	Check arm of K605A (fig. 256).
	S601C does not operate, properly or at proper time.	Cam C plates not properly adjusted.	Check cam C plate setting (fig. 252).
			Check cam C positioning (fig. 252).
	Minor switch K605 does not step to contact No. 2 when S601C operates.	Switch S601C defective	Replace S601C (fig. 252).
		Switch S601D defective	Check switch S601D (fig. 252).
		Minor switch K605 defective	Check K605 off-normal contacts (fig. 256).
	Relay K603 does not energize after S601C operates.	Relay K603 (fig. 251) defective	Check K603 coil (fig. 255).
			Check K603 contacts (fig. 255).
	Relay K603 energizes after S601C operates but will not hold.	Relay K603 defective	Check K603 contacts (fig. 255).
	Relay K602 does not hold when S601C operates. (K603 will not hold either, in this case.)	Relay K603 defective	Check K603 contacts (fig. 255).
	−12 volts dc not present at terminal 8 after K603 energizes.	Relay K603 defective	Check K603 contacts (fig. 255).

Item	Indication	Probable trouble	Procedure
4	When alarm is simulated—Con.		
	S601D does not operate properly, or at proper time.	Cam D plates not properly adjusted.	Check cam D plate settings (fig. 252). Check cam D positioning (fig. 252).
	Relay K604 does not energize when S601D operates.	Switch S601D defective	Check S601D contacts (fig. 252).
		Relay K604 defective	Check K604 coil resistance (fig. 254).
	−12 volts dc not present at terminal 6, after K604 energizes.	Relay K604 defective	Check K604 contacts (fig. 254). Check arm and contact 2 of K605B (fig. 256).
5	Motor of S601 does not stop at end of cycle, when cam A releases S601A.	Switch S601A defective	Replace switch S601A (fig. 252).
6	Power failure test (removing 115-volt power when cycle is finished) does not release K605 arm to home position.	Relay K606 defective	Replace K606 (fig. 251).
		Minor switch K605 defective	Check K605 off-normal contacts (fig. 256). Check K605 release mechanism (fig. 256).

407. Additional Troubleshooting Data

a. Additional troubleshooting information can be gained by continuity checks on the straight-through wiring of the C–1840/FRN–22. These checks should be made with all external connections removed. The points of measurement are readily seen on the schematic diagram (fig. 141).

b. Repairs to working parts, such as relays, minor switches, and sequential switches, are described in chapter 5.

Section XXII. RADIO TRANSMITTER T–573/FRN–20 TROUBLESHOOTING

408. General

Troubleshooting the transmitter may be accomplished in the CY–1899/FRN–22 or on the test bench. The transmitter front panel meter provides important basic troubleshooting information in either case, and should be referred to frequently during troubleshooting. Transmitter troubleshooting may be performed while the alternate equipment is performing the normal omnirange navigational functions.

***Warning:* Extremely high voltages are present during all portions of transmitter troubleshooting. Take adequate precautions against electrical shock. Make tests with power off whenever possible; while discharging capacitors, use insulated tools, and keep hands and tools dry at all times.**

409. Troubleshooting Reference Data

The following list of illustrations on chart will be useful during troubleshooting the transmitter.

Fig. No.	Caption
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
19	Radio Transmitter T–573/FRN–20, tube and crystal locations.
36	Radio Transmitter T–573/FRN–20, control locations.
47	Oscilloscope modulation patterns.
275	Radio Transmitter T–573/FRN–20, schematic diagram.
195	Radio Transmitter T–573/FRN–20, bench test setup.
196	Radio Transmitter T–573/FRN–20, voltage and resistance diagram.
257	Radio Transmitter T–573/FRN–20, showing capacitors.
258	Radio Transmitter T–573/FRN–20, showing resistors.
259	Radio Transmitter T–573/FRN–20, rear view.
260	Radio Transmitter T–573/FRN–20, bottom view.
261	Radio Transmitter T–573/FRN–20, neutralizing capacitor adjustment.
314	Radio Transmitter T–573/FRN–20, wiring diagram.

410. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting the transmitter is listed below, with the applicable technical manual and common name assigned to each.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.
Electronic Multimeter TS–505/U.	TM 11–5511	vtvm.
Oscilloscope, DuMont, Type 2559A.		Oscilloscope.
Audio Oscillator TS–382A/U.	TM 11–2684A	AF oscillator.
Frequency Meter AN/URM–32.	TM 11–5120	Frequency meter.
RF Wattmeter AN/URM–43A.	TM 11–5133	Load wattmeter.

b. Additional Equipment Required. The additional equipment required to troubleshoot the transmitter is listed below with its common name.

Qty	Description	Common name
1	Power Supply PP–1331/FRN–20	
1	Fabricated interconnecting cable (par. 413*b*).	Power supply cable.
1	Safety door switch (cap portion) Bryant Electric Co. No. 4600A. (Federal Stock No. 5930–757–4130.)	Interlock jumper plug.
1	Adapter, connector type N to type BNC, UG–201/U.	Adapter.

411. Removal and Reinstallation

a. Removal. Disconnect plugs P1, P1806, and P1807 (fig. 16). After removing the cabinet trim strips, remove the panel screws and the transmitter.

b. Reinstallation. Carefully guide the transmitter RF output cable through the cabinet opening, replace the transmitter, and fasten it with the panel screws. Reinstall the trim strips and plugs P1, P1806, and P1807 (fig. 16).

412. General Precautions

a. Controls. Do not change any of the control settings or the transmitter tuning adjustments during troubleshooting. Unless the front panel meter readings are being observed, set transmitter meter switch S2 in the HIGH VOLTAGE SCALE 100 X 10 position to avoid possible damage to the meter by an accidental short circuit during troubleshooting.

b. Short and B+ Test. Prior to energizing the transmitter or connecting to the bench test setup, make the resistance measurements listed in the chart below. This will avoid additional damage to the transmitter or the PP–1331/FRN–20. Use the multimeter and discharge the test point to chassis before connecting the meter. All checks are between chassis and test points unless otherwise specified.

Test point	Resistance (ohms)	Part tested
Pin 7 of J1 (fig. 259).	30K	Capacitors C3, C9, and C15.
Pin 6, V2 (fig. 258)	45K	Capacitor C8.
Pin 3, V3	10–25K	Capacitor C13.
Pin 12, J1	Infinite	−25-volt bias line.
Pin 11, J1	Infinite	−75-volt bias line.

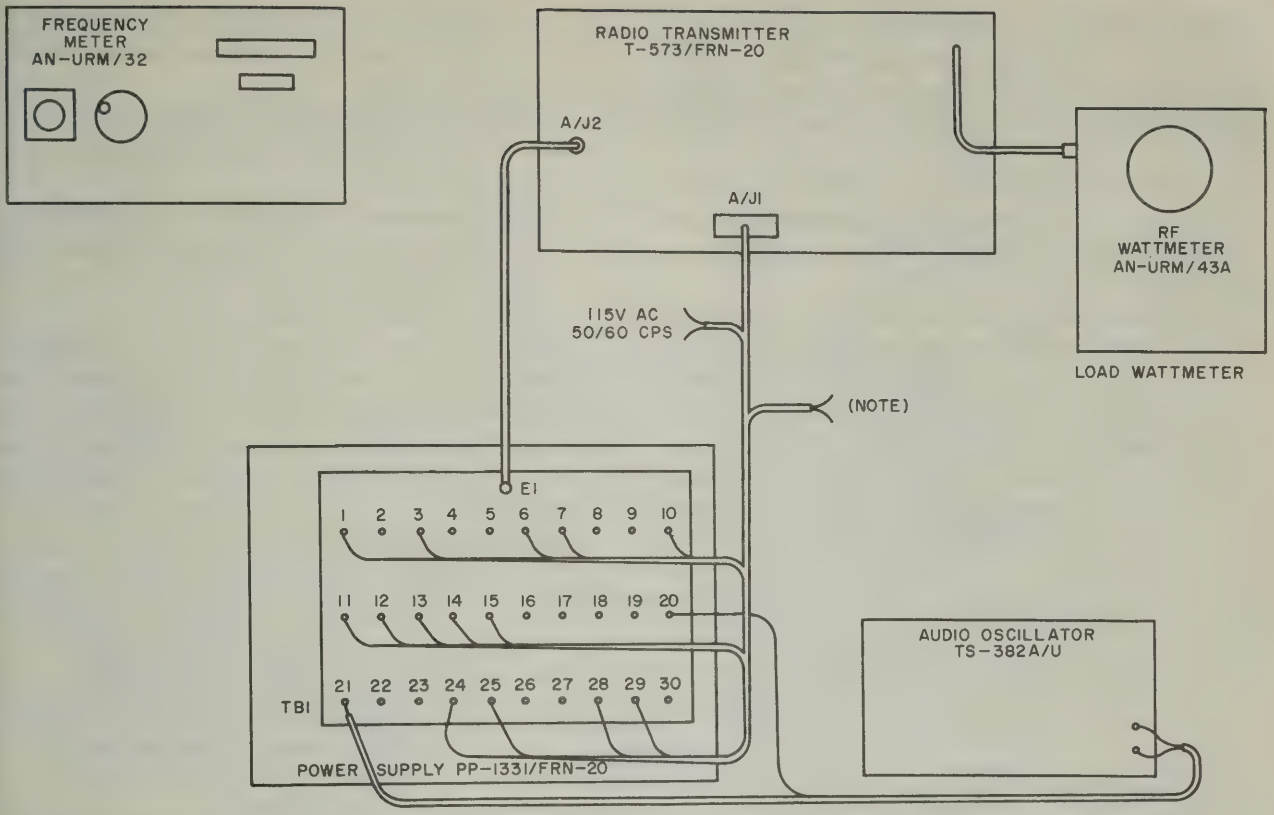
413. Bench Test Setup

a. General. Normally the transmitter will be serviced in the operating position, but when bench servicing, use the bench test setup provided in this paragraph. The bench test setup will require a PP–1331/FRN–20 which has been tested in accordance with specifications contained in chapter 6.

b. Cable Fabrication. The connections between receptacles J1 and J2 of the transmitter (fig. 259) and terminal board TB1 of the PP–1331/FRN–20 (fig. 243) must be fabricated as indicated in the chart below.

Item and use	Wire size	Length
Electrical plug connector, H. B. Jones Co. part No. S 315 FHT, at J1 (fig. 259).		
Electrical plug connector James Millen Co. part No. 37001 (plug), at J2.		
Wire connections between the PP–1331/FRN–20 and J1.	#18 AWG	25 ft.
Wire connections between the PP–1331/FRN–20 and J2.	#18 AWG (HV).	30 in.

c. Transmitter Power. The PP–1331/FRN–20, which is used with the transmitter under normal operating conditions, is the best power source for bench testing the unit. It is not considered prac-



NOTE
THIS TEST SET UP REQUIRES THE SAME TEST CABLE AS PREVIOUSLY USED IN TESTS DESCRIBED IN PARAGRAPH 468 AND ILLUSTRATED IN FIGURE 229 WITH THE EXCEPTION THAT NO CONNECTION IS MADE TO THE MODULATION ELIMINATOR MX-1843/FRN-20 .

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Figure 195. Radio Transmitter T–573/FRN–20, bench test setup.

ticable to build a substitute supply that would be an exact duplicate of the PP–1331/FRN–20.

d. Test Procedure.

(1) Remove the transmitter and the PP–1331/FRN–20 from the cabinet (par. 411).

(2) Connect the test cable between the transmitter and the PP–1331/FRN–20.

(3) Connect the load wattmeter to the RF output plug P1 (fig. 259) of the transmitter.

(4) Remove the front access panel of the transmitter and install the interlock jumper plug.

(5) Use the adapter and connect the oscilloscope to receptacle J3 (fig. 257) on the transmitter.

(6) Connect the audio oscillator to the PP–1331/FRN–20 (fig. 195).

(7) Connect the PP–1331/FRN–20 to 115 volts ac and turn on the power switch.

414. Troubleshooting with Radio Transmitter T–573/FRN–20 Installed

Troubleshooting the transmitter while installed is usually accomplished with the other equipment operating. Refer to section III for the proper procedure to turn on one equipment for maintenance while the other equipment is on the air. The load wattmeter should be connected to receptacle J1802 at the top of CY–1899/FRN–22 (fig. 226). The audio oscillator referred to in the bench test setup will not be needed.

415. Localizing Troubles

Warning: **Extremely high voltages exist in the transmitter during all portions of the troubleshooting procedure. Take every precaution to avoid electrical shock.**

a. General. Perform the troubleshooting procedures indicated in the chart after the operational check has been made. Compare the results of the operational check with the reported transmitter faults to be certain that it is possible to duplicate the fault for troubleshooting. A lack of reported indications may be due to improper test connections or the trouble may be in another unit.

b. Operational Check. To localize the fault, perform all the following operational steps in sequence before proceeding with the troubleshooting chart.

(1) Turn meter switch S2 (fig. 36) to the HIGH VOLTAGE position. The meter should indicate a minimum of 500 volts.

(2) Observe the wattmeter indication. Normal indication is approximately 50 watts.

(3) Turn meter switch S2 to the FINAL AMP GRID position. Normal indication is 7 to 10 ma.

(4) Turn meter switch S2 to the 2ND AMP GRID position. Normal indication is 1.4 to 3 ma.

(5) Turn meter switch S2 to the 1ST AMP GRID position. Normal indication is 1 to 1.6 ma.

(6) Turn meter switch S2 to the MOD TOTAL position. Normal indication unmodulated is 55 ma. Normal indication modulated is 70 ma.

c. Use of Chart. To use the chart, check the *Indication* column for the trouble symptoms observed during the operational check, note the probable troubles that may exist, and apply the corrective procedure given for that trouble. Note all references.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	Meter M1 does not indicate 500 volts with S2 in the HIGH VOLTAGE position.	Defective resistor	Check resistor R19 (fig. 258).
		Defective switch	Check meter switch S2.
		Defective meter	Check meter M1.
		Shorted capacitor	Check capacitor C25 (fig. 259).
2	M1 does not indicate 1 to 1.6 ma with S2 in 1ST AMP GRID position.	Defective oscillator stage	Check V1 (fig. 259). Check crystal Y1. Make voltage and resistance measurements at V1 (fig. 196). Check capacitor C5 (fig. 257) by substitution. Check adjustment of OSC PLATE tuning capacitor C4 (par. 39).
3	M1 does not indicate 1.4 to 3 ma with S2 in 2ND AMP GRID position.	1ST DBLR AMPL stage defective	Check V2. Make voltage and resistance measurements at V2 (fig. 196). Check capacitor C11 (fig. 257) by substitution. Check adjustment of 1ST AMP PLATE tuning capacitor C10 (par. 39).
4	M1 does not indicate 7 to 10 ma with S2 in FINAL AMP GRID position.	2ND DBLR AMPL stage defective	Check U3. Make voltage and resistance measurements at V3 (fig. 196). Check coupling between L5 and L4 (fig. 260). Check adjustment of EXCITATION CONTROL R8 (par. 39). Check adjustment of 2ND AMP PLATE control C14 (par. 39).
5	Wattmeter does not indicate 50 watts.	FINAL AMPL stage defective	Check V4 (fig. 259). Make voltage and resistance measurements at V4 (fig. 196). Check adjustment of FINAL AMP GRID tuning capacitors C16 and C17 (par. 39). Check adjustment of FINAL AMP PLATE tuning capacitors C20 and C21 (par. 39). Check positioning of inductor L8 (par. 39).

Item	Indication	Probable trouble	Procedure
6	Oscilloscope indicates no modulation and M1 does not indicate 55 ma with S2 in MOD TOTAL position.	MOD APPL stage defective	Check V7 and V8. Make voltage and resistance measurements at V7 and V8 (fig. 196).
7	Same as 6 except that M1 does indicate 55 ma.	AUDIO DRIVER stage defective	Check V5 and V6. Make voltage and resistance measurements at V5 and V6 (fig. 196). Check transformers T1 and T2 (par. 417*b*). Check attenuator AT1 (fig. 258) setting.
8	Oscilloscope indicates low modulation.	One stage defective	Make stage-gain check (par. 416). Check adjustment of AT1 (par. 45).

416. Stage Gain

Use the procedures given below to locate a defective stage in the modulator section when the modulation percentage is low.

a. Disconnect the wires from terminals 3 and 6 of terminal board TB1 on the PP–1331/FRN–20 (fig. 243) and turn attenuator AT1 to the full clockwise position.

b. Stage gains for the indicated input signal and the test points are shown in the following chart. Apply the indicated signal voltage of 1,000 cps; take measurements at the indicated test points in the order given and calculate stage gains. If gains are low, check all components of that stage.

Step	Input connections	Input	Test points	Stage gain
1	Pin 3 of V7 and V8 (fig. 258)	30	Terminals 1 and 3 of T3 (fig. 259)	66. 6
2	Pin 1 of V5 and V6	2. 5	Terminals 1 and 3 of T3	80
3	Terminals 3 and 6 of TB1 on Power Supply PP–1331/FRN–20.	0. 1	Terminals 1 and 3 of T3	2, 000

417. Isolating Trouble

a. Voltage and Resistance Measurements. Before using figure 196, contained in separate envelope, read the notes carefully, then duplicate the test setup and obtain valid measurements. The voltage and resistance measurements are used to assist in isolating faulty parts after a defective stage has been located. When the defective part is located, check associated parts to determine whether another part caused the failure.

b. Transformer and Inductor Resistance. The dc resistance values in the chart below can be used to assist in isolating a transformer that is open or shorted.

Transformer or inductor	Connection points	Resistance (ohms)
L1 (fig. 258)	Across leads	Less than 1.
L2	Across leads	Less than 1.
L3	Across leads	Less than 1.
L4 (fig. 260)	Across leads	Less than 1.
L5	Across leads	Less than 1.
L6 (fig. 259)	Across leads	29.
L7	Across leads	Less than 1.
L8	Across leads	Less than 1.
T1	1–2	1,650.
	1–3	3,300.
	4–6	27.
T2	1–2	17.
	1–3	35.
	4–5	167.
	4–6	340.
T3	1–2	20.
	1–3	45.
	1–4	64.
T4	0–115	5.
	Secondary	Less than 1.

418. Additional Troubleshooting Data

a. Tube Substitution. Under some circumstances, even though tubes have been tested with the tube tester, it may be necessary to substitute one or more new tubes of known quality to be certain that a tube is not the cause of trouble in a defective stage. Never leave a new tube in the socket if the unit operates satisfactorily with the original tube.

b. Parts Substitution. Another procedure to use for hard-to-find difficulties is the substitution of parts that are known to be functioning properly for suspected parts. Be sure to disconnect the suspected part before connecting the known temporary part. Do not leave the new part in the unit unless it corrects the difficulty.

Section XXIII. RELAY ASSEMBLY RE–247/FRN–22 TROUBLESHOOTING

419. General

a. The RE–247/FRN–22 contains control relays and switches which apply primary power to the power supplies of the two transmitting equipments as directed by dialing procedures. The four switches on the RE–247/FRN–22 (two switches for each) provide manual control of the transmitting equipments for testing.

b. The RE–247/FRN–22 can be serviced in the operating position or at the test bench. Normally, service at the test bench is more convenient and safer.

420. Troubleshooting Reference Data

The following list of illustrations on chart will be helpful in troubleshooting.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
36	Relay Assembly RE–247/FRN–22, fuse location.
290	Relay Assembly RE–247/FRN–22, schematic diagram.
197	Relay Assembly RE–247/FRN–22, bench test setup.
262	Relay Assembly RE–247/FRN–22, top view.
263	Relay Assembly RE–247/FRN–22, rear view.
264	Relay adjustment data.
315	Relay Assembly RE–247/FRN–22, wiring diagram.

421. Equipment Required

a. Test Equipment. The following test equipment is required for troubleshooting. Test equipment is listed with the applicable technical manual and assigned common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U__	TM 11–6625–203–12.	Multimeter.

b. Additional Equipment Required. The following additional equipment is required for troubleshooting.

Qty	Description	Common name
1	10-connector female plug H. B. Jones Co. part No. S 310 FHT (Federal Stock No. 5935–283–2889).	Power plug.
1	12-connector male plug H. B. Jones Co. part No. P 412 CCT (Federal Stock No. 5935–296–8912).	Test plug.
1	6-inch lead with alligator clips at each end.	Clip lead.
2	Power cable with suitable plugs at each end.	Power cable.
1	Tool equipment TE–113________	Tool kit.

422. Removal and Reinstallation
(fig. 16)

a. Removal. To remove the RE–247/FRN–22, remove plugs P401, P808, P813, P823, and P825. Remove the cabinet trim strips, chassis mounting screws, and withdraw the chassis.

b. Reinstallation. To reinstall the RE–247/FRN–22, set it in the cabinet opening and replace the chassis mounting screws and cabinet trim strips. Reconnect plugs P401, P808, P813, P823, and P825 to their proper receptacles.

423. General Precautions

a. Controls may be left in their normal operating positions (switches for both equipments set on 460A and OFF).

b. Before applying power or initiating other troubleshooting procedures, make a visual inspection and a quick short circuit test between each plug or receptacle terminal and terminal 2 of receptacle J401 (fig. 263).

424. Bench Test Setup

a. Connections for bench tests are shown in figure 197.

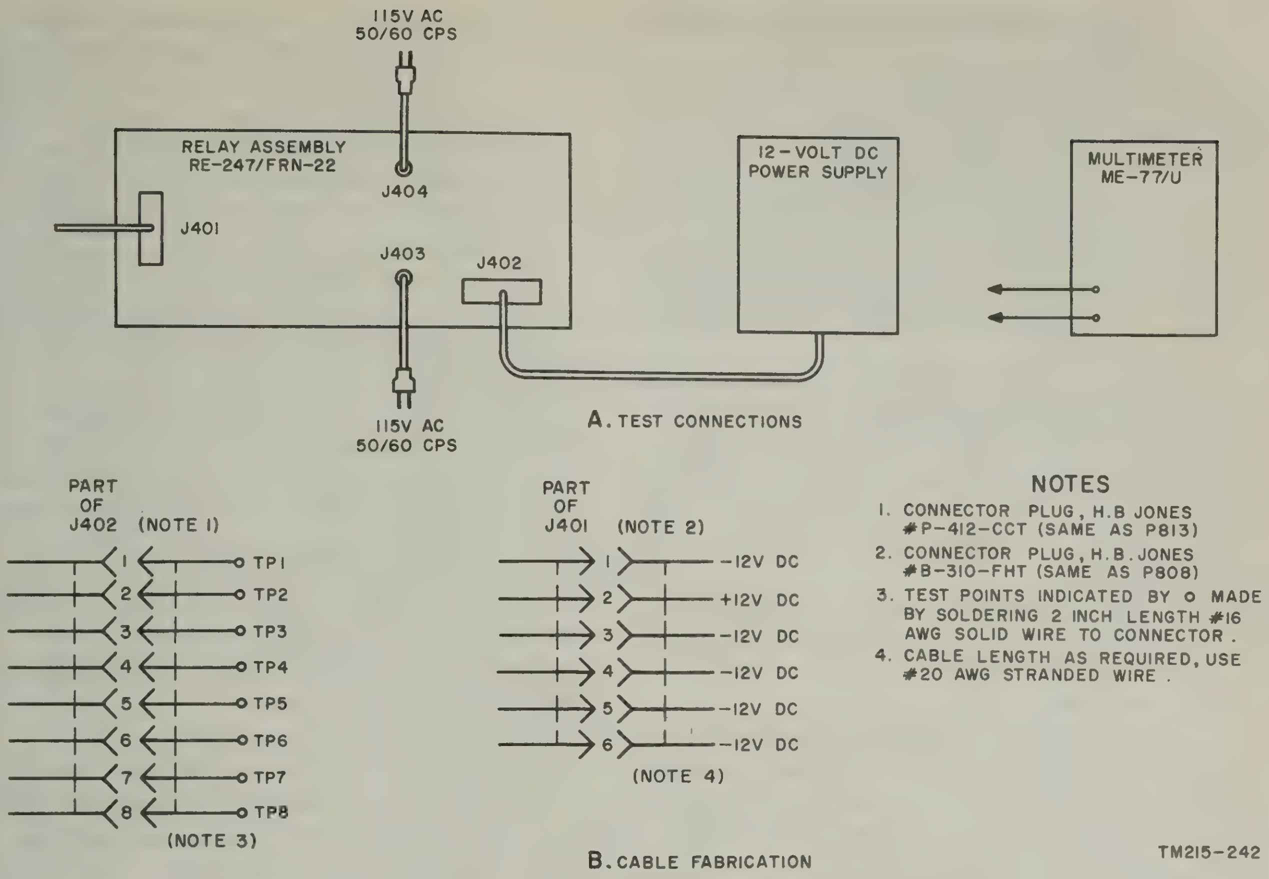


Figure 197. Relay Assembly RE-247/FRN-22, bench test setup.

b. The bench test requires two proper sources.

1. (1) A source of 115 volts, 50 or 60 cps ac, with adequate switching for control of power application.
2. (2) A source of 12 volts dc at 1 ampere with adequate switching to control power application.

c. Make the following test connections:

1. (1) Use female plug H. B. Jones, part No. S 310 FHT, obtained from bulk or spare supplies. Wire the power plug (B, fig. 197).
2. (2) Use male plug H. B. Jones, part No. P 412 CCT, obtained from bulk or spare supplies. Wire the test plug (B, fig. 197).

425. Troubleshooting Procedures

(figs. 263, 264)

a. Procedures for troubleshooting consist of observing relay operation as energizing voltages are applied and measuring voltages controlled by these relays at output receptacle J402 (fig. 263).

b. Follow procedures given below for checking equipment No. 1 automatic control circuits.

(1) Apply 115-volt ac power to receptacles J403 and J404.

(2) Apply +12 volts dc to terminal 2 of receptacle J401.

(3) Apply —12 volts dc to terminal 3 of receptacle J401. Relay O 401 should close, placing 115 volts ac at terminals 3 and 4 of receptacle J402.

  (*a*) If relay O 401 closes but 115 volts ac does not appear at terminals 3 and 4 of J402, check the contacts of O 401, receptacle J403, wiring from J403 to O 401, and from O 401 to J402.

  (*b*) If relay O 401 does not close, check the winding resistances of O 401, check switch S401, receptacle J401; and associated wiring.

(4) Apply —12 volts dc to terminal 4 of receptacle J401, leaving other voltage connections in place. Relay O 402 should close, placing 115 volts ac at terminals

1 and 2 of J402, with O 401 remaining closed.

(*a*) If O 402 closes, but 115 volts ac is missing from terminals 1 and 2 of J402, check the contacts of O 401 and O 402, check receptacles J402, J403, J404, and associated wiring.

(*b*) If O 402 does not close, check winding resistance of O 402, switches S401 and S402, receptacle J401, and associated wiring.

c. Follow procedures given below for checking equipment No. 1 manual control circuits.

(1) Set switch S401 (fig. 262) to TEST.

(2) Apply 115 volts ac to J403 and J404.

(3) Apply +12 volts dc to terminal 2 of J401 and —12 volts dc to terminal 1 of J401.

(4) Set switch S402 to ON. Relays O 401 and O 402 should close, making 115 volts ac available at terminals 1 and 2 and at terminals 3 and 4 of J402.

(*a*) If the relays close, but either or both 115-volt outputs are missing, check contacts of both relays, receptacles J403 and J402, and associated wiring.

(*b*) If either or both relays fail to close, check the winding resistance of the open relay; check J401, S401, S402, and associated wiring.

(5) Return S401 and S502 to normal (down). Disconnect the —12 volts dc from terminal 1 of J401.

d. To check equipment No. 2 automatic-control circuits, proceed as follows:

(1) Apply 115-volt ac power to receptacles J403 and J404.

(2) Apply +12 volts dc to terminal 2 of receptacle J401, and —12 volts dc to terminal 5 of J401. Relay O 403 should close, placing 115-volt ac to terminals 7 and 8 of J402.

(*a*) If relay O 403 closes, but 115 volts ac is missing from terminals 7 and 8 of J402, check the contacts of O 403, J403 and J402, and associated wiring.

(*b*) If O 403 does not close, check the winding resistance of O 403, switch S403, J401, and associated wiring.

(3) Apply —12 volts dc to terminal 6 of J401, leaving other voltage connections in place. Relay O 404 should close, placing 115 volts ac at terminals 5 and 6 of receptacle J402, with O 403 remaining closed.

(*a*) If relay O 404 closes but 115 volts ac is missing from terminals 5 and 6 of J402, check contacts of O 404 and O 403, J402, J403, J404, and associated wiring.

(*b*) If relay O 404 does not close, check the winding resistance of O 404, J401, S403, and associated wiring.

e. To check equipment No. 2 manual-control circuits, proceed as follows:

(1) Set switch S403 to TEST.

(2) Apply 115 volts ac to J403 and J404.

(3) Apply +12 volts dc to terminal 2 of J401, and —12 volts dc to terminal 1 of J401.

(4) Set switch S404 to ON. Relays O 403 and O 404 should close, placing 115 volts ac at terminals 5 and 6 and at terminals 7 and 8 of J402.

(*a*) If both relays close, but either or both 115-volt ac outputs are missing, check contacts of O 403 and O 404, J402, J403, and J404, and associated wiring.

(*b*) If either or both relays fail to close, check winding resistance of the open relay, check J401, S403, S404, and associated wiring.

f. Before returning the RE–247/FRN–22 to service in the omnirange set, make a final test, based on troubleshooting continuities, and rerun the operational check.

Section XXIV. RELAY ASSEMBLY RE–248/FRN–22 TROUBLESHOOTING

426. General

a. The RE–248/FRN–22 contains relays which are controlled by dial pulses from the C–1738/FRN–20 to switch the signal and control voltages between the two transmitting equipments. Also included are a test switch, receptacle, and jacks for testing one transmitting equipment while the other is in operation.

b. The RE–284/FRN–22 can be serviced in place in the control cabinet but removal to the test bench is more convenient and safer.

427. Troubleshooting Reference Data

The following list of illustrations on chart will be useful during troubleshooting.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
289	Relay Assembly RE–248/FRN–22, schematic diagram.
198	Relay Assembly RE–248/FRN–22, bench test setup.
248	Relay adjustment data.
265	Relay Assembly RE–248/FRN–22, interior view.
266	Relay Assembly RE–248/FRN–22, rear view.
267	Relay adjustment data.
316	Relay Assembly RE–248/FRN–22, wiring diagram.

428. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting is listed below with the applicable technical manual and the common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.

b. Additional Equipment. The additional equipments required to troubleshoot the RE–248/FRN–22 are listed below with their common names.

Qty	Description	Common name
1	6-inch wire lead with alligator clips on each end.	Test lead.
1	Tool Equipment TE–113	Tool kit.
1	Female 24-connector plug H. B. Jones Co. part No. S 324 FHT (Federal Stock No. 5935–644–7410).	Test and power plug.
2	Female 10-connector plugs H. B. Jones Co. part No. S 310 FHT (Federal Stock No. 5935–283–2889).	Test plugs.

429. Removal and Reinstallation

a. Removal. To remove the RE–248/FRN–22 for bench testing, disconnect plugs P805, P806, and P807 (fig. 16). Remove the cabinet trim strips and chassis mounting screws. Withdraw the RE–248/FRN–22 from the cabinet.

b. Reinstallation. To reinstall, replace it in the cabinet opening, replace the chassis mounting screws, cabinet trim strips, and reconnect plugs P805, P806, and P807.

430. General Precautions

a. The position of the only control, the MOD ELIM TEST switch, is unimportant during testing; this portion of the circuit is not under test.

b. Make a visual inspection and short-circuit test before applying power or initiating other troubleshooting procedures. Check the resistance between chassis (terminal 24 of receptacle J301 in figure 266) and other terminals of J301, J303, and J304.

431. Bench Test Setup

a. Connections for bench testing are shown in figure 198.

b. Power required for bench tests consists of a 12-volt ac, 1-ampere source with adequate switching to control power application.

c. Make up the following test connectors:

(1) Use an H. B. Jones, part No. S 324 FHT, obtained from bulk or spare supplies, and make up the test and power plug (B, fig. 198).

(2) Use an H. B. Jones, part No. S 310 FHT, obtained from bulk or spare supplies, and make up the two test plugs (B, fig. 198).

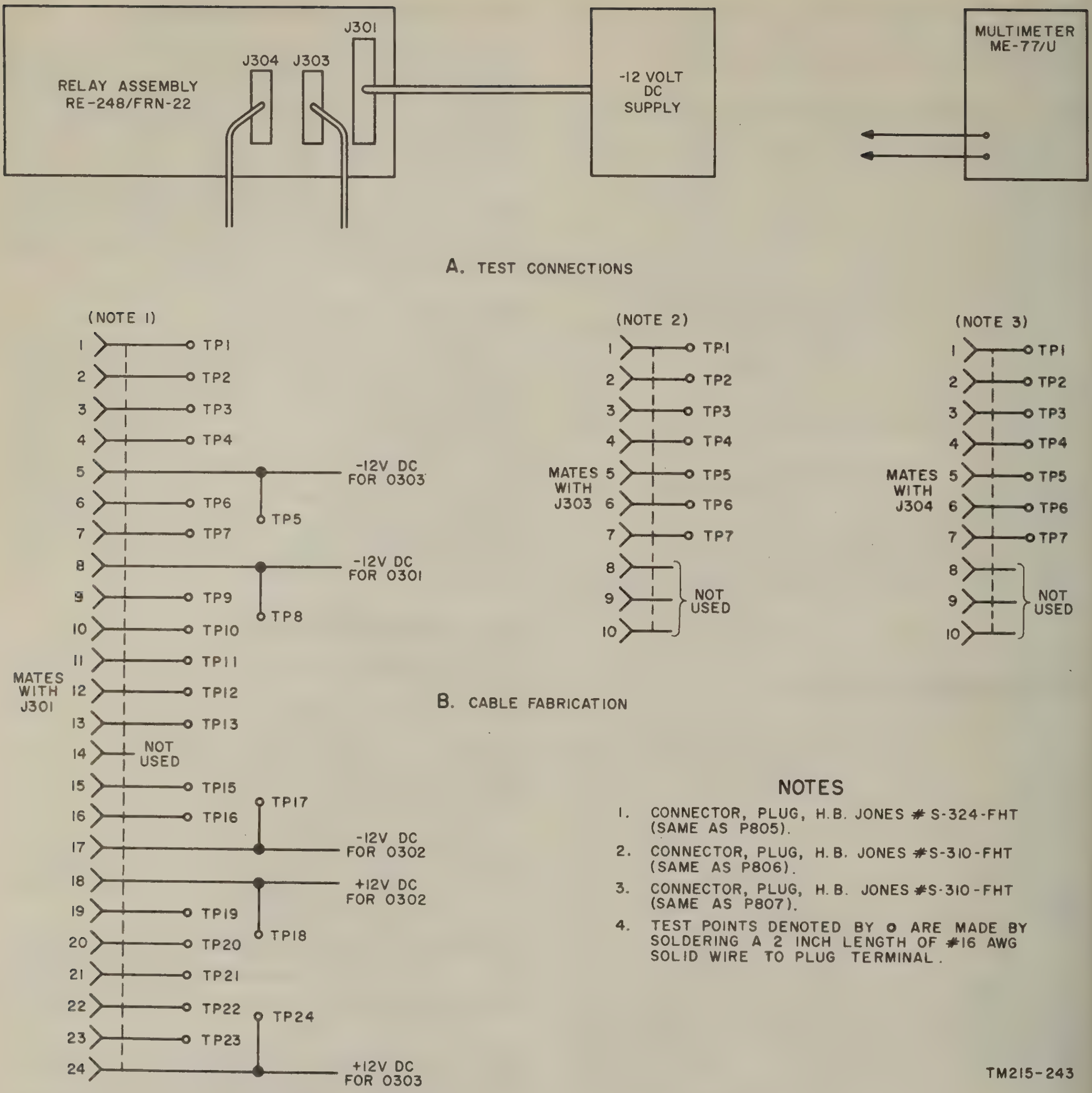
432. Troubleshooting Procedures

a. With the RE–248/FRN–22 disconnected, refer to the schematic diagram (fig. 289) and make continuity checks between the terminals of receptacle J301 and J303 or J304 (fig. 256).

b. Apply 12 volts dc, as indicated in the test setup, to energize the three relays and again make continuity checks between the terminals of J301 and J303 or J304.

433. Final Test

Before returning the RE–248/FRN–22 back to service in the omnirange set, make a final test based on troubleshooting procedures (par. 432).



NOTES

1. CONNECTOR, PLUG, H.B. JONES # S-324-FHT (SAME AS P805).
2. CONNECTOR, PLUG, H.B. JONES #S-310-FHT (SAME AS P806).
3. CONNECTOR, PLUG, H.B. JONES #S-310-FHT (SAME AS P807).
4. TEST POINTS DENOTED BY o ARE MADE BY SOLDERING A 2 INCH LENGTH OF #16 AWG SOLID WIRE TO PLUG TERMINAL.

Figure 198. Relay Assembly RE–248/FRN–22, bench test setup.

Section XXV. VOLTAGE REGULATOR CN–358/FRN–22 TROUBLESHOOTING

434. General

The voltage regulator is located in the CY–1897/FRN–22 cabinet. When troubleshooting the voltage regulator, notify the proper authorities that the station is off the air for maintenance. For reason of accessibility, it is preferable to remove the unit from the cabinet for service. Troubleshooting should be accomplished close to the omnirange set, so that it can be used as a load. Use the information in this section to obtain a complete and accurate diagnosis of trouble. To avoid additional damage or difficulties, be sure to complete the short test (par. 438*b*) and perform a thorough visual inspection before applying power. If special repair procedures are required after the trouble has been located, refer to chapter 5.

435. Troubleshooting Reference Data

The following list of illustrations on chart will be useful during troubleshooting of the voltage regulator.

Fig. No.	Caption
13	Electrical Equipment Cabinet CY–1897/FRN–22, component installation diagram.
16	Radio Transmitting Set AN/FRN–22A, cording diagram.
26	Voltage Regulator CN–358/FRN–22, tube and fuse locations.
34	Voltage Regulator CN–358/FRN–22, fuse, control, and indicator locations.
291	Voltage Regulator CN–358/FRN–22, schematic diagram.
148	Ac power distribution circuits, schematic diagram.
199	Voltage Regulator CN–358/FRN–22, test setup.
200	Voltage Regulator CN–358/FRN–22, voltage and resistance diagram.
268	Voltage Regulator CN–358/FRN–22, front view.
269	Voltage Regulator CN–358/FRN–22, rear view.
270	Voltage Regulator CN–358/FRN–22, subchassis interior view.
302	Electrical Equipment Shelter S–120/FRN–22, wiring diagram.
317	Voltage Regulator CN–358/FRN–22, wiring diagram.

436. Equipment Required

a. Test Equipment. The test equipment required for troubleshooting is listed below with the applicable technical manual and the common name.

Test equipment	Technical manual	Common name
Multimeter ME–77/U	TM 11–6625–203–12.	Multimeter.

Additional Equipment. Additional equipment required to troubleshoot the voltage regulator is listed below with its common name.

Qty	Description	Common name
1	Cable, bench test, P1 to J1	Test cable.
3	Jumper wire	Jumper.

437. Removal and Reinstallation

Although special techniques are not required for removing or replacing the voltage regulator, make certain that circuit breaker K1001 on the antenna pedestal (fig. 201) is in the off position.

a. Removal. Turn off circuit breaker K1001 and disconnect the three wires at terminal board TB1 on the rear of the voltage regulator (fig. 269). Loosen the eight screws at the sides of the front access panel. Withdraw the voltage regulator from the cabinet.

b. Reinstallation. Replace the voltage regulator in the cabinet and tighten the eight screws on the front panel. Reconnect the three wires to terminal board TB1. Set circuit breaker K1001 to the on position.

438. General Precautions

a. Controls. Two screwdriver adjustments (R12 INCREASE OUTPUT VOLTAGE AND R13 INCREASE SENSITIVITY) are located behind access holes in the front panel (fig. 268). Do not change these settings during troubleshooting unless specifically told to do so.

b. Short Test. Before power is applied, make a visual inspection to insure that receptacles and terminal boards for power input and output are in working order and that tubes are properly seated in their sockets. With the voltage regulator disconnected, refer to figure 269 and measure the dc resistance between terminal 4 of terminal board TB1 and chassis. An infinite value of resistance should be obtained. If a finite value is obtained, check transformers T1, T2, T3, T4, and T5 for a defect before applying power.

439. Bench Test Setup

a. General. The test setup is shown in figure 199. A variable transformer should be used to vary the input voltage to check the compensating action of the voltage regulator. The omnirange set is used as the load for the voltage regulator. The subchassis of the voltage regulator is removed, opened, and connected to the main chassis by a test cable, to perform the troubleshooting procedures.

b. Cable Fabrication. The test cable between the main chassis of the voltage regulator and the subchassis must be fabricated as indicated in the following chart.

Item and use	Wire size	Length
Electrical plug connector, H. B. Jones Co. part No. S 2408 FHT (Federal Stock No. 5935–259–204), at P1 on subchassis.		
Electrical plug connector, H. B. Jones Co. part No. P 2408 FHT (Federal Stock No. 5935–259–204), at J1 on main chassis.		
Wire, connections between P1 on subchassis and J1 on main chassis.	#16 AWG	24 ft

c. Test Procedure.

(1) Turn circuit breaker K1001 (fig. 201) off.

(2) Remove the voltage regulator from the cabinet (par. 437*a*).

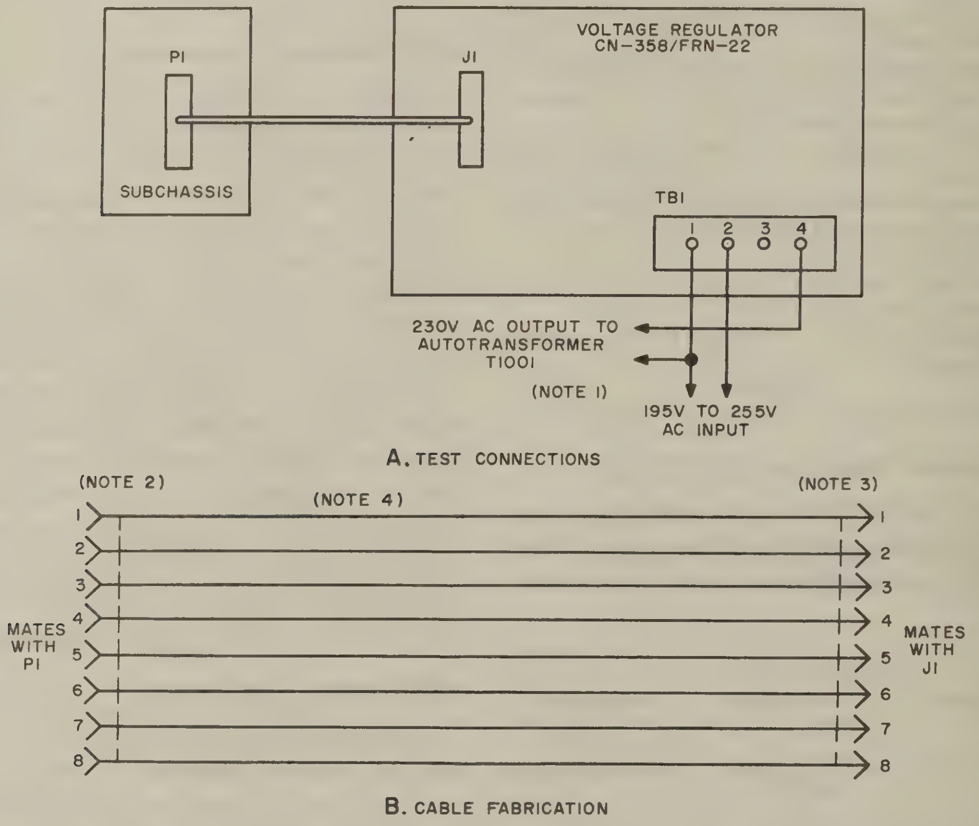
(3) Connect the voltage regulator to autotransformer T1001.

(4) Apply 230 volts ac to the voltage regulator.

440. Localizing Troubles

a. General. Troubleshooting the voltage regulator by use of the chart below is a systematic method of isolating a defective part.

b. Preliminary Operational Check. To prevent the introduction of additional troubles, check the test setup for secure and correct connections. Apply 230 volts ac to the input and check for such



NOTES

1. USE #10 TW WIRE BETWEEN INPUT SOURCE AND TO OUTPUT CONNECTIONS.
2. CONNECTOR PLUG, H.B. JONES #S-2408-FHT
3. CONNECTOR PLUG, H.B. JONES #P-2408-FHT
4. CABLE LENGTH AS REQUIRED, USE #16 AWG STRANDED WIRE.

TM215-244

Figure 199. Voltage Regulator CN–358/FRN–22, bench test setup.

defects as overheating transformers, smoking components, cold tubes, or blown fuses.

c. Use of Chart. To use the chart, check the Indication column for the trouble symptoms observed, note the probable troubles that may exist, and apply the corrective procedure given for that trouble. Use all paragraph references.

d. Troubleshooting Chart.

Item	Indication	Probable trouble	Procedure
1	No output	Defective circuit breaker	Check circuit breaker K1 (fig. 268).
		Defective transformer	Check transformer T4 (par. 441*b*).
2	No indication on meter M1	Blown fuse	Check fuses F1 and F2 (fig. 269).
		Defective meter	Check meter M1.
3	Indicator lamp I 1 does not light	Blown fuse	Check fuse F4.
		Defective lamp	Check lamp I 1.
		Defective transformer	Check transformer T5 (par. 441*b*).
4	V1 and V2 filaments do not light	Defective tubes	Check V1 and V2.
		Defective transformer	Check transformer T1 (par. 441*b*).
5	Motor does not operate to correct the output with a change of input or a change in load.	Blown fuse	Check fuses F3 and F5.
		Defective tube	Check V1 and V2.
		Defective relay	Check by substitution relays RL1 and RL2 and resistor assembly R2 (fig. 269).
			Make voltage and resistance measurements (fig. 200).
		Defective motor	Check motor B1.
6	Motor operates but output voltage does not change.	Defective brushes	Replace brushes (ch. 5).

441. Isolating Trouble

a. Voltage and Resistance Measurements. Before using figure 200, contained in separate envelope, read the notes on it carefully to duplicate the setup and obtain valid measurements. The voltage and resistance measurements are used to help isolate faulty parts after a defective stage has been located. When the defective part is located, check associated parts to determine whether another part caused the failure. (A shorted capacitor can overload an associated resistor.)

b. Transformer Resistance. The transformers in the voltage regulator have very low dc resistance; therefore, the measurement of a winding to determine whether a winding is open is all that is necessary.

442. Additional Troubleshooting Data

A procedure for hard-to-find difficulties is the substituting of parts that are known to be functioning properly for suspected parts. Be sure to disconnect the suspected part before connecting the good temporary part. Do not leave the new part in unless it corrects the difficulty.

CHAPTER 5

REPAIRS AND ALINEMENT

Section I. REPAIRS

443. General Parts Replacement Techniques

Parts replacement in Radio Transmitting Set AN/FRN–22A is covered by individual paragraphs for each component within this section. The following precautions should be observed during repair work.

a. When replacing parts near an RF inductor, or the inductor itself, avoid bending or repositioning the inductor windings. Replace all tap connections in the same positions as the original.

b. Do not attempt the replacement of parts of a relay, minor switch, or lever switch. Replace the complete component part and adjust it in accordance with applicable instructions.

c. Exercise extreme care when soldering to feed-through capacitors, diode rectifiers, and hermetic seals, to avoid overheating. Grasp the lead between the solder point and the seal with a pair of pliers to dissipate the heat.

d. Removal and reinstallation procedures are contained in the appropriate paragraph in chapter 4 and special parts replacement procedures are contained in the specific paragraph of this section.

e. Components and parts requiring lubrication are listed in paragraph 223. Perform the applicable procedure to the unit undergoing repair or during parts replacement.

444. Coaxial Cable Fabrication and Repair

Repairs to and fabrication of coaxial cables used in the omnirange set are very critical. This paragraph describes the various procedures for the fabrication of coaxial cables for the omnirange set.

a. Cable Lengths. The table of coaxial cables contained in paragraph 445*b* lists the coaxial cables with critical dimensions. *Do not deviate from these lengths at any time.* When defective cables require repairs which necessitate shortening, a new cable must be fabricated.

b. Coaxial Connectors. Physically damaged connectors must be replaced because repairs are not permissible. Figure 274 illustrates the two types of connectors used in the omnirange set and contains assembly instructions. Do not substitute coaxial connectors of a different type from those specified in the parts list for the omnirange set. During assembly, be extremely careful to avoid loose shield braid strands inside the connector. Loose strands will either short the connector or cause a change in impedance of the cable. Follow the step-by-step procedure given in figure 274 and be sure that the center pin can be pushed into the plug or does not protrude too far out of the plug.

c. Coaxial Cable. Examine all coaxial cables for dents or cuts. Discard any cable with such damage because either type will deteriorate rapidly or vary in impedance. Coaxial cable that has aged a long time without the ends sealed should be examined carefully. If the end does not appear fresh and pliable, cut off several inches until the fresh material is reached. When stripping the outer protective covering from coaxial cable, do not cut the shield braid. Such damaged strands will cause future cable troubles.

d. Variable Carrier Feed Cables. In some cases difficulty may be encountered in balancing of power fed to the two variable carrier feed lines, due to unequal cable characteristics. Length, connectors, and coaxial cable quality are the chief elements involved. To remedy this situation, make two new cables of the exact length from the same bulk supply of cable.

e. Testing Fabricated or Repaired Coaxial Cables. After fabrication or repair of a coaxial cable, check the cable by the procedures given in paragraph 255. The reflected power percentage must be less than 1 percent and the difference between matched coaxial cables less than ½ of 1 percent.

445. Wiring Harness and RF Cable Repair

a. Wiring Harness Repair. When wires in wiring harnesses are broken or damaged, replace them with new wires of the same color, size, and type as the original.

b. RF Cable Repair. Defects in RF cables most commonly occur at or near the connectors. In many cases, to repair such a defect, it would be necessary to reduce the length of the cable. Because the length of most RF cables used in the omnirange set is quite critical, it usually will be necessary to construct a new cable rather than repair the old one. Before repairing or constructing an RF cable, refer to the chart below to determine which cables have critical lengths and what their overall lengths should be. All cables listed in the chart are shown in figure 16. Cables which are part of a component are identified by name in the chart.

Cable designation	Overall length
W–2	132 ± ⅛ in.
W–3	116 ± ¼ in.
W–4	132 ± ⅛ in.
W–5	14 ± ⅛ in.
W–13	60 ± ⅛ in.
W–14	60 ± ⅛ in.
W–15	60 ± ⅛ in.
W–16	60 ± ⅛ in.
W–17	60 ± ⅛ in.
W–18	60 ± ⅛ in.
Variable carrier output cable (attached to receptacle J1801 or J1803 in the CY–1899/FRN–22).	14 ± 1/32 in.
Reference carrier output cable (attached to receptacle J1802 in the CY–1899/FRN–22).	68 ± ⅛ in.
Transmitter output cable (attached to transmitter).	15⅝ ± ½ in.

446. Replacement of Electrical Goniometer GO–12/FRN–20 Drive Belt

a. Use the telephone dial on the C–1738/FRN–20 to turn on the transmitting equipment in which the goniometer drive belt is *not* being replaced. Dial 9, then 8, to turn on transmitting equipment No. 1. Dial 7, then 6 to turn on transmitting equipment No. 2.

b. On the goniometer, loosen the motor base mounting bolts (fig. 30) and remove the drive belt.

c. Install a new drive belt and aline the belt between the pulleys.

d. Position the motor for 1 inch of play in the drive belt. Then tighten the motor base mounting bolts.

e. To prevent excessive drive belt wear, the drive belt and motor pulley must be alined carefully so that, as the goniometer motor operates, the drive belt will remain centered on the motor pulley and not rub against the face of either pulley flange. Dial the transmitting equipment into operation and observe the drive belt as the goniometer motor operates.

f. If the drive belt does not remain centered on the motor pulley, dial 10 to turn the equipment off. Reposition the goniometer motor slightly.

g. Repeat the procedures given in *e* and *f* above until the dial belt is properly alined.

447. Relay Repair

a. General. The repair procedure for all relays is contained in the following paragraphs. Each part requires an adjustment and cleaning method which constitutes the only repairs permissible. An illustration (fig. 202) has been provided which contains specific data for adjustment. Technical manual TM 11–2103 contains additional information applicable to these parts, and will be a primary guide to all procedures. Specific information on the unusual relays of the omnirange set is contained in the paragraphs describing the repairs to the unit of which they are a part.

b. Open Frame Relays. The following steps apply to the open frame type relays and should be used with the illustration data applicable to the specific relay.

(1) Burnish contacts lightly with flat-blade Burnisher TL–557/U until minor pits and scores are removed. Examine contacts under a strong light with a magnifying lens. Remove dirt and film from contacts with cleaning compound.

> ***Caution:* Never use emery cloth, sandpaper, or a file to clean contacts. Do not burnish deeply pitted or burned contacts; replace the relay.**

(2) Disconnect all external connections from the component (fig. 16) and one lead from the relay coil. Measure the coil resistance with the multimeter and compare the values with chart values.

(3) Connect a variable source of voltage (ac or dc, shown in chart) across the relay coil and slowly increase the voltage until the relay pulls in. Measure the voltage with the multimeter and compare it with the chart value. Adjust the spring anchor as required to obtain the correct pull-in voltage.

(4) Measure the deenergized contact gap with a thickness gage and compare the gap with the chart value. Bend the lower stationary contacts as required to obtain the proper gap.

(5) Manually move the relay armature until the contacts just close; measure the gap between the armature and the core. Compare the gap with the contact overtravel value in the chart. Bend the movable point to obtain the desired overtravel.

(6) Manually hold the armature in the fully energized position (armature against core) and measure the pressure required (adjacent to contact) to just break the contacts with Gram Gauge TL–559/U. contact arms at the armature attach Compare the energized pressure with the chart value.

(7) Release the relay armature and measure the pressure (adjacent to contact) required to just break the contacts. Compare the deenergized pressure with the chart value.

(8) Check the contacts of both sections to insure that the contacts make and break at approximately the armature position. Reconnect the relay coil lead and the external connections that were removed in the procedure given in (2) above.

c. Telephone-Type Relays. Telephone-type relays are repaired, cleaned, and adjusted in accordance with procedures given in TM 11–2103. The data given in the illustrations for this section contain information required to test and adjust the relays in the omnirange set.

(1) The contact arrangement, shown in the data illustrations, is viewed from the relay mounting end.

(2) Relay coil resistances are dc and measured with the multimeter.

(3) Minimum back contact pressure is measured with Gram Gauge TL–559/U.

(4) Test (operate and nonoperate or release) values are the voltages applied to determine whether adjustment is necessary. Use a variable power source which starts at zero output and monitor with the multimeter. The relay is acceptable if tolerances are met without tension adjustments.

(5) Adjust values are those which must be obtained when adjustment is required under the tests given in (4) above. The relay must energize fully at the voltage or current given under adjust-operate conditions and not under adjust-nonoperate conditions.

448. Antenna Pedestal Repair

a. The replacement of the circuit breakers mounted on the antenna pedestal requires no special procedures except the complete removal of all power input. Unless other means of disconnect were provided at the time of installation, it will be necessary to have the power shut off at the input to the site. Do not attempt to repair any circuit breakers. Figure 201 will assist in the location of the parts of the antenna pedestal.

b. Repairs to relays N/K1008, N/K1009, and N/K1010 consist only of cleaning and adjustment. Do not attempt the replacement of any integral parts. The contacts normally do not require cleaning; however should it become necessary, remove the threaded cap in the contact block and burnish the normally closed (NC) contacts (fig. 202) lightly with flat-blade Burnisher TL–557/U. Clean the normally open (NO) contacts by manually energizing the relay clapper. If contacts are burned excessively, replace the complete relay assembly. To adjust the contact pressures, complete the following steps:

(1) Check the pressure of the NC contacts by unscrewing the threaded cap over the contacts and inserting Gram Gauge TL–559/U behind the spring arm adjacent to the contact. The amount of pressure required to just open the contacts should be between 30 and 45 grams.

(2) If the NC contact pressure is not within limits, remove the four block screws (fig.

202) and disassemble the block and plate. Increase the contact pressure by bending the arm slightly past the center. Reassemble the block and plate, and recheck the pressure value.

(3) To check the NO contacts, manually hold the relay clapper in the energized position. Insert the gram gage adjacent to the contact and measure the pressure required to just open the contacts. The pressure must be within the 30- to 50-gram limits.

(4) To adjust the NO contact pressure, release the clapper and place a .020- to .040-inch shim between the clapper and coil core (fig. 202). Bend the NO clapper arm in small increments, remove the shim, manually energize the relay, and recheck the pressure. Repeat this procedure until 30 to 50 grams is obtained.

(5) Check the relay backstop by holding the clapper against the back stop and measuring the clearance between the NO clapper arm and the NO pusher pin. This value should be .010 to .020 inch.

(6) To adjust the back stop clearance, bend the back stop as required to obtain the correct NO pusher pin clearance. While holding the clapper against the stop, bend the NC clapper arm to obtain .010 to .020 inch clearance between the clapper arm and the NC pusher pin.

(7) The grounding function of the contacts against the block is not critical and should be between 10 and 30 grams.

(8) To adjust the grounding pressure of the NC contact, bend the NC clapper arm as required. Adjust the NO grounding pressure by disassembling the block and plate and bend the NO spring arm. Bend this arm at a point as close as possible to the NO coaxial connector receptacle. Always recheck procedures (1) through (6) above when grounding adjustments are made.

449. Antenna AT–669/FRN–22 Repair

a. General. The repairs to the antenna are limited because of the complexity of the test facilities required to properly adjust the antenna after repair. Do not under any circumstances repair, remove, adjust or otherwise disturb any parts of the antenna or feed lines except as directed in the following paragraphs. The views of figures 39, 41, 42 and 43 illustrate the location of parts of the antenna for assistance during repairs.

b. Radome Repair. Cracked or badly weathered radomes must be replaced. Only in extreme emergencies, when all possibilities have been exhausted to obtain a replacement, is it permissible

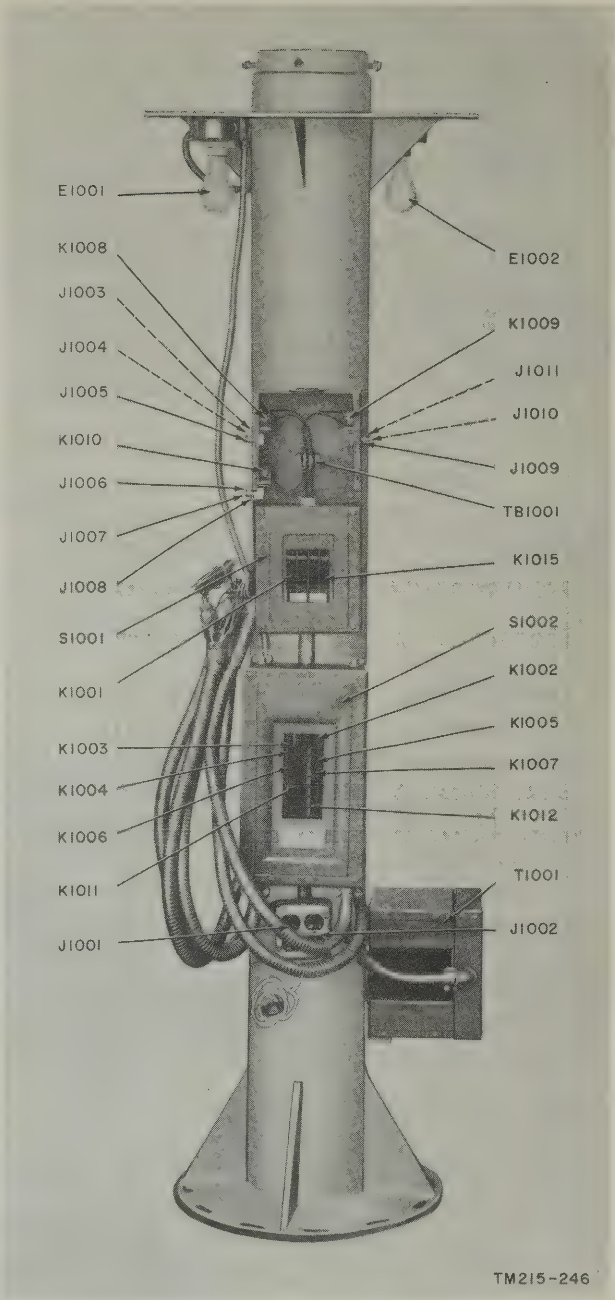
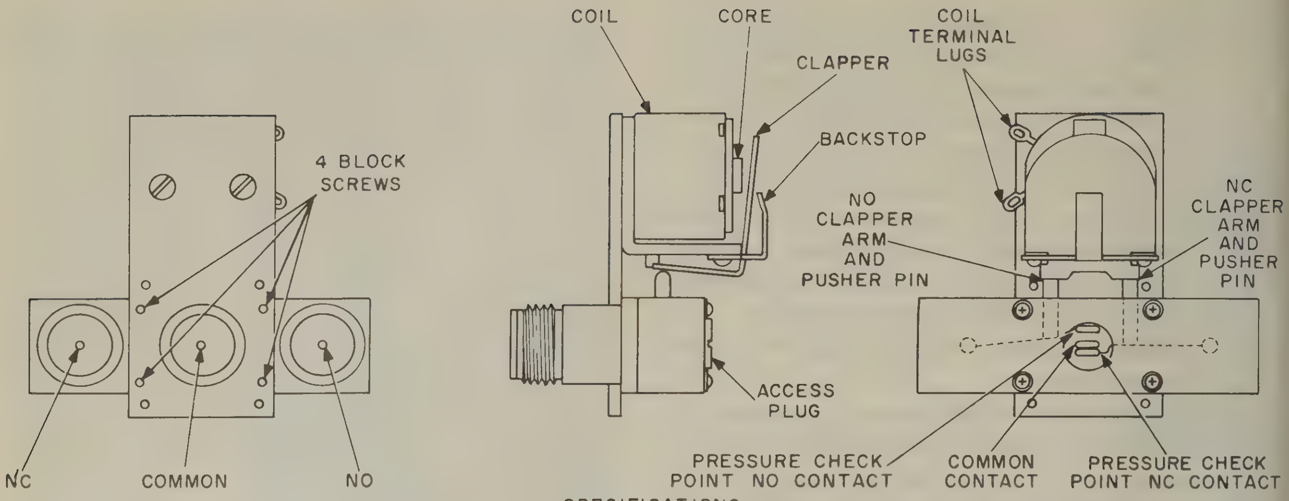


Figure 201. Antenna pedestal.


COIL
CORE
COIL TERMINAL LUGS
CLAPPER
BACKSTOP
4 BLOCK SCREWS
NO CLAPPER ARM AND PUSHER PIN
NC CLAPPER ARM AND PUSHER PIN
ACCESS PLUG
NC
COMMON
NO
PRESSURE CHECK POINT NO CONTACT
COMMON CONTACT
PRESSURE CHECK POINT NC CONTACT

SPECIFICATIONS

NC CONTACT PRESSURE	NO CONTACT PRESSURE (ENERGIZED)	BOTH CONTACTS GROUNDING PRESSURE	COIL RESISTANCE	PULL-IN VOLTAGE
30-45 GRAMS	30-50 GRAMS	15-25 GRAMS	550 ±10% OHMS	80-95V AC

Figure 202. Relay adjustment data.

to patch or otherwise repair a radome. Do not use compounds which contain any metal or conductive particles. When removing radomes, identify them with the slot. Replace any defective gaskets and take all necessary precautions to make the joints weathertight.

c. Coaxial Cable Replacement. Complete cable repair instructions are given in paragraphs 444 and 445. Refer to figure 274 for assembly instructions of cables to position them exactly as the original. Do not overtighten clamps. This procedure may damage the cable or jacket.

d. Feeder Capacitor Replacement. Feeder capacitors C1 and C2 (fig. 43) are replaced by removing the two screws and spacers that hold them to the antenna cylinder and replacing the complete capacitor assembly. Do not attempt internal repairs to these capacitors. Upon reinstallation, loosen the dial lock and set the dial to the value shown in the chart shipped with the antenna. Be sure to lock the dial after setting and tighten the coaxial connectors.

e. Heater Repair. Heater repairs consist of the repair of broken connections and wiring re-

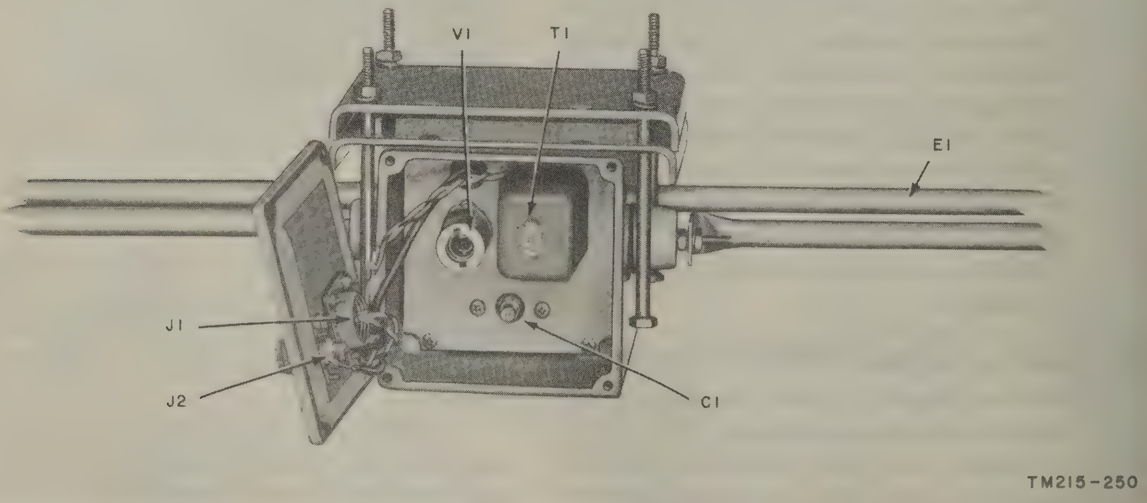


Figure 204. Antenna Group AN/FRA-14, bottom interior view.

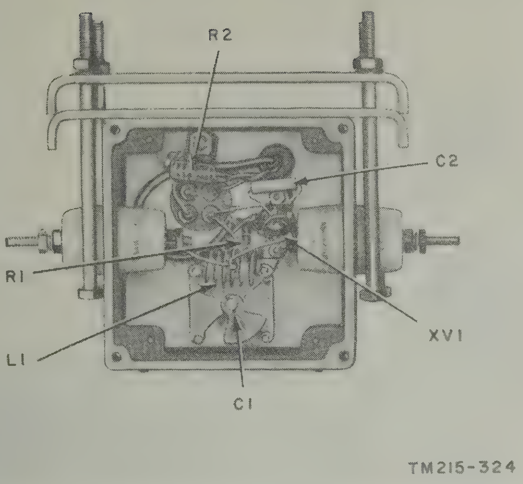


Figure 205. Antenna Group AN/FRA-14, top interior view.

placement by standard procedures of good practice. The replacement of a heater element will require the removal of the screws and clamps (fig. 203, contained in separate envelope) which fasten the heater element and connecting leads. The heater may then be manipulated into position to gain access to the connecting terminals. It is not necessary to remove or disturb any of the RF parts of the antenna during heater replacement. Be sure that connections made to the replacement heater element are tight, to avoid oveheating the connection. Be sure that the connections are adequately insulated with tape to prevent shorts.

450. Antenna Group AN/FRA-14 Repair

No special procedures are required for repairs to the AN/FRA-14. Avoid disturbing the tuned circuit elements (L1/C1 in fig. 205). Figure 205 will be helpful in locating the component parts in the AN/FRA-14.

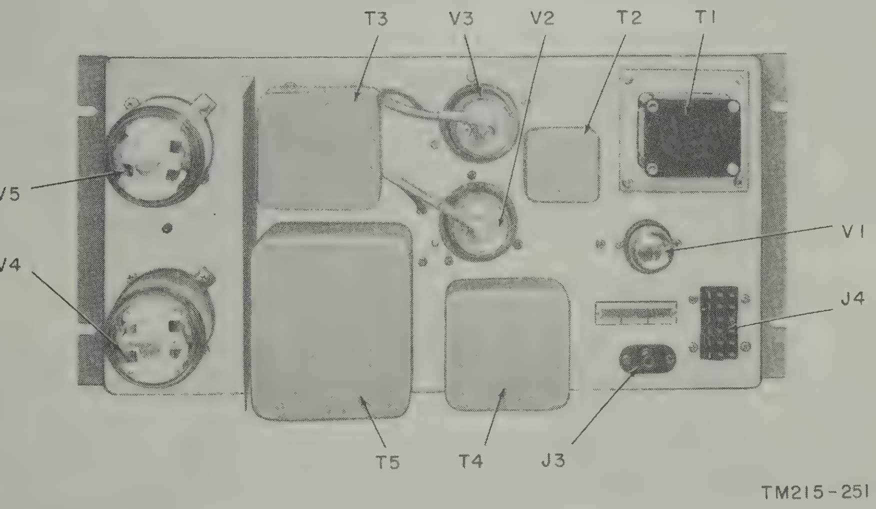


Figure 206. Audio Frequency Amplifier AM-1246/FRN-20, interior view.

451. Audio Frequency Amplifier AM-1246/FRN-20 Repair

The AM-1246/FRN-20 has no unusual repair requirements. Figure 206 illustrates the correct part locations for replacement purposes. Adjustment data for relay G/S2 are shown in figure 221. General instructions are given in paragraph 500.

452. Audio Frequency Amplifier AM-1247/FRN-20 Repair

No special procedures are required to complete repairs in the AM-1247/FRN-20. Use figures 209 and 210 for parts location.

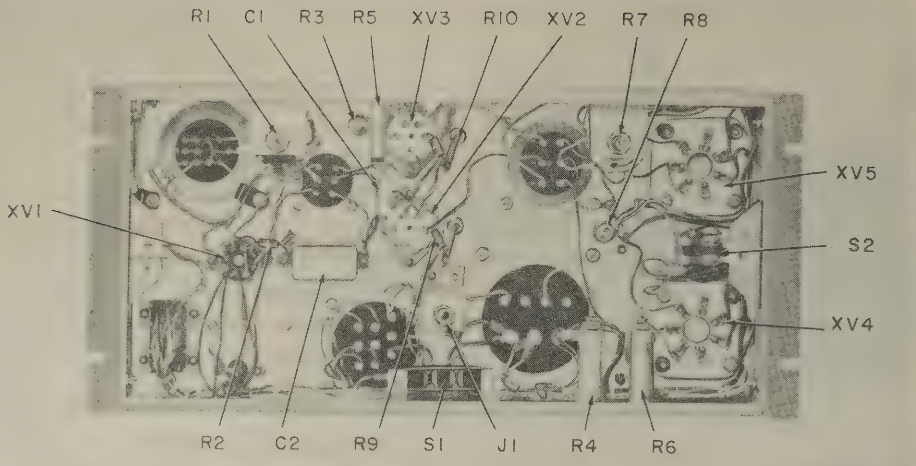


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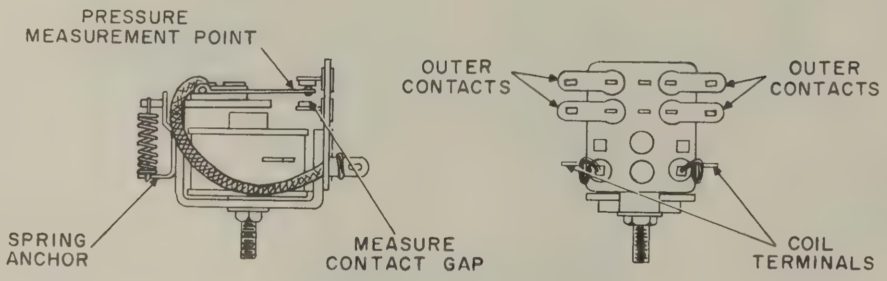
Figure 207. Audio Frequency Amplifier AM–1246/FRN–20, rear view.

CONTACT GAP MIN	CONTACT OVERTRAVEL MIN	DEENERGIZED PRESSURE MIN	ENERGIZED PRESSURE MIN	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
.010 INCH	.005 INCH	15 GRAMS	20 GRAMS	250 ±10%	6.9 ± 1V DC
ADJUSTMENT PROCEDURE PARAGRAPH: 447 b					

REFERENCE DESIGNATOR	EQUIPMENT
B/K1	MODULATION ELIMINATOR MX-1843/FRN-20
G/S2	AUDIO FREQUENCY AMPLIFIER AM-1246/FRN-20
S4 AND S5	POWER SUPPLY PP-1331/FRN-20

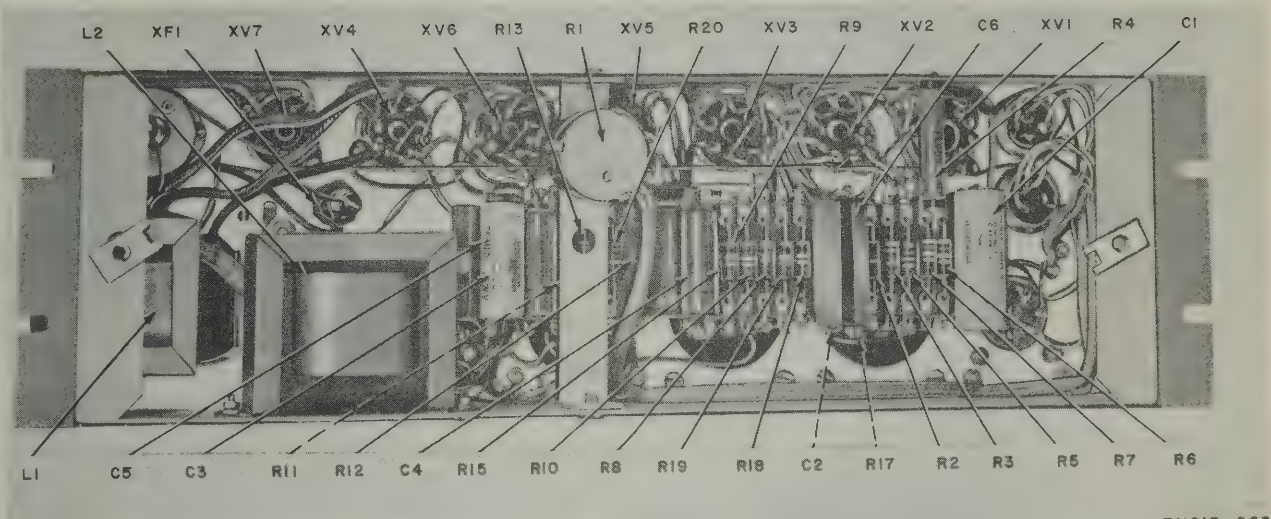


TM215-252

Figure 208. Relay adjustment data.

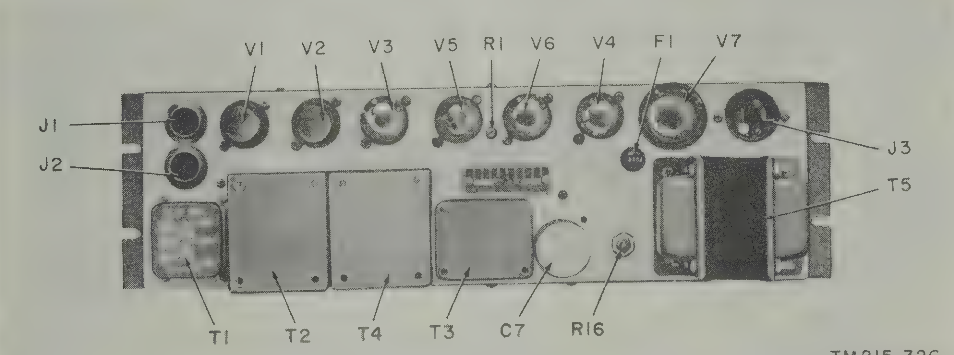
453. Audio Frequency Oscillator O–371/FRN–20 Repair

The O–371/FRN–20 has no unusual repair requirements. Figures 211, 212, and 213 illustrate the correct parts location for replacement purposes. Adjustment data for relay K901 are shown in figure 214. General instructions are given in paragraph 447.



TM215-253

Figure 209. Audio Frequency Amplifier AM–1247/FRN–20, interior view.



TM215-326

Figure 210. Audio Frequency Amplifier AM–1247/FRN–20, rear view.

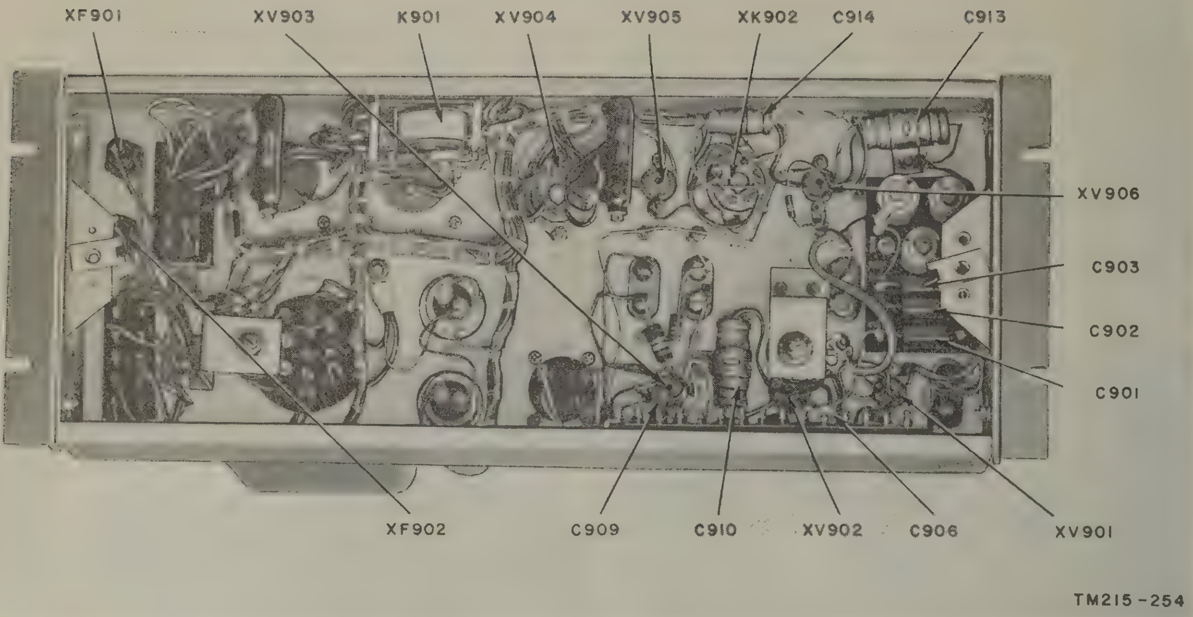


Figure 211. Audio Frequency Oscillator O–371/FRN–20, exterior view.

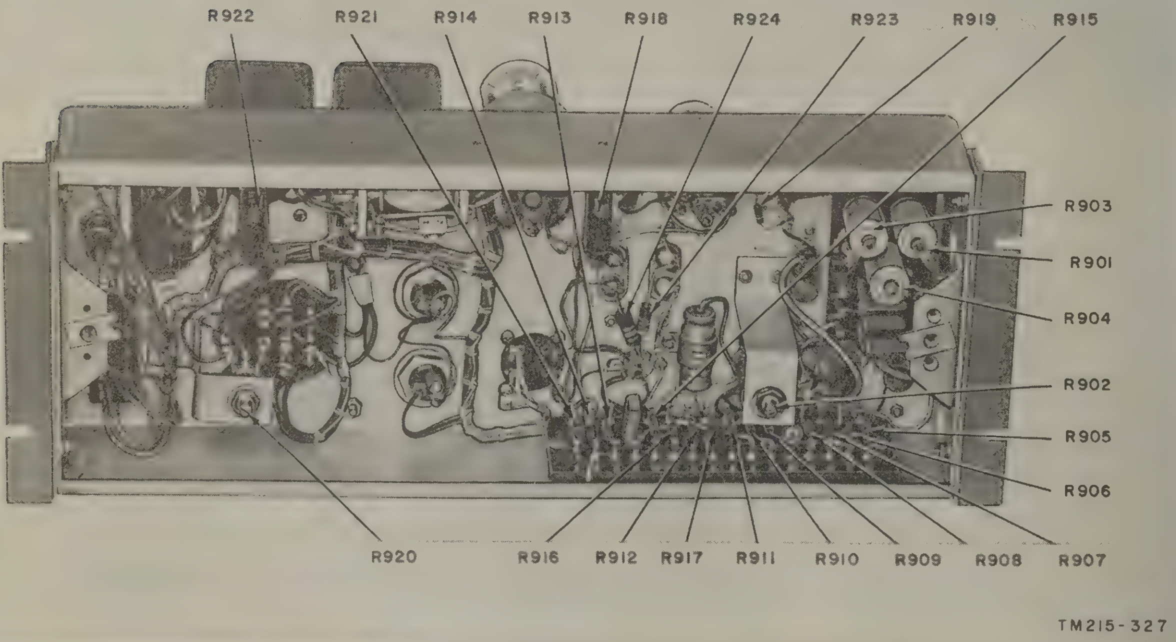


Figure 212. Audio Frequency Oscillator O–371/FRN–20, interior view.

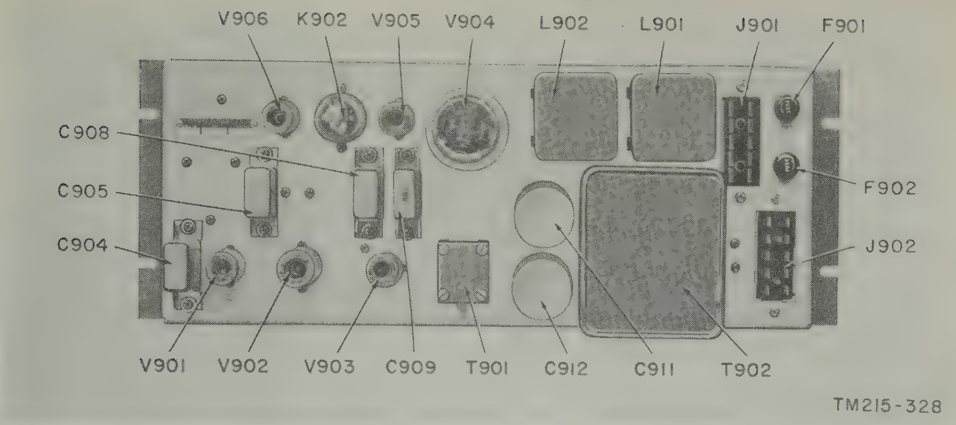
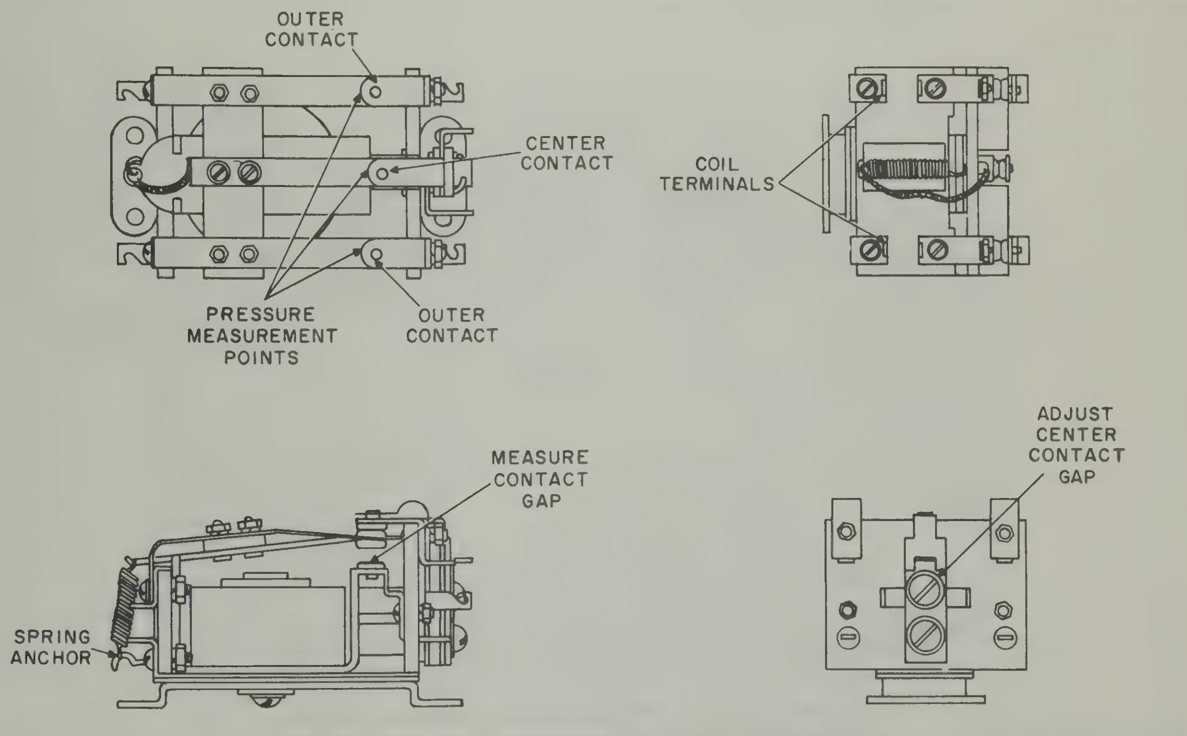


Figure 213. Audio Frequency Oscillator O–371/FRN–20, rear view.

<table>
<tr><th>CONTACT LOCATION</th><th>CONTACT GAP MIN</th><th>CONTACT OVERTRAVEL MIN</th><th>DEENERGIZED PRESSURE MIN</th><th>ENERGIZED PRESSURE MIN</th><th>COIL RESISTANCE (OHMS)</th><th>PULL IN VOLTAGE</th></tr>
<tr><td>CENTER</td><td>.050 INCH</td><td>.010 INCH</td><td>5 GRAMS</td><td>7 GRAMS</td><td rowspan="2">600 ±10%</td><td rowspan="2">85 ± 5 V AC</td></tr>
<tr><td>OUTER</td><td>.055 INCH</td><td>.010 INCH</td><td>15 GRAMS</td><td>20 GRAMS</td></tr>
<tr><td colspan="7">ADJUSTMENT PROCEDURE PARAGRAPH: 447 b</td></tr>
<tr><td colspan="3">REFERENCE DESIGNATOR</td><td colspan="4">EQUIPMENT</td></tr>
<tr><td colspan="3">K901</td><td colspan="4">AUDIO FREQUENCY OSCILLATOR O-371/FRN-20</td></tr>
</table>



TM215-255

Figure 214. Relay adjustment data.

454. Audio Frequency Oscillator O–373/FRN Repair

No special procedures are required to complete repairs in the O–373/FRN. Use figures 215 and 216 for part locations and standards of good workmanship for all part replacements.

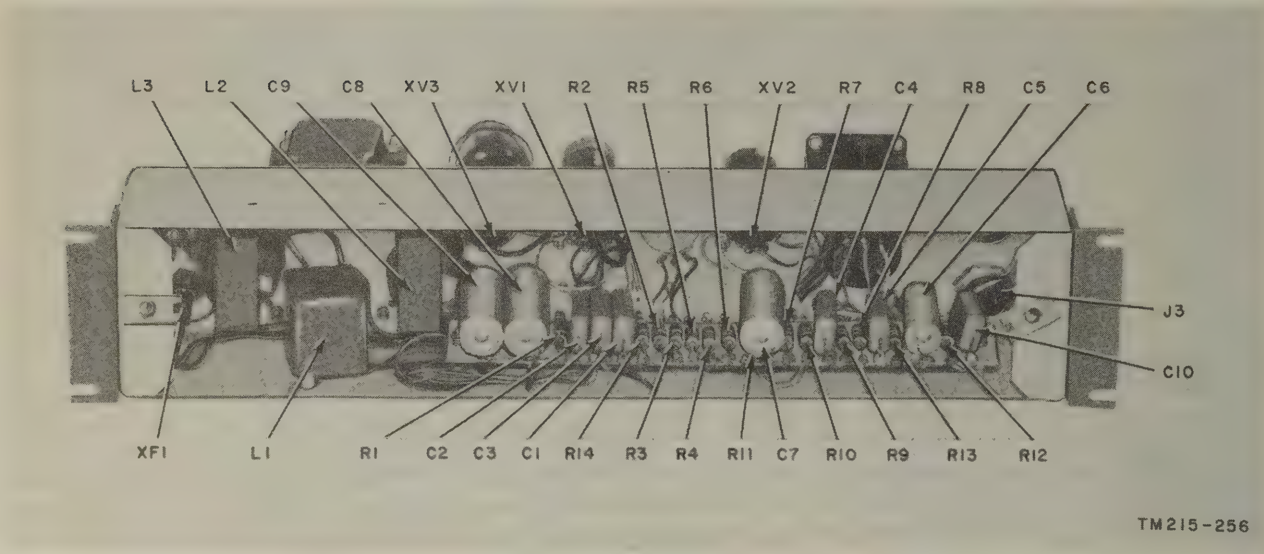


Figure 215. Audio Frequency Oscillator O–373/FRN, interior view.

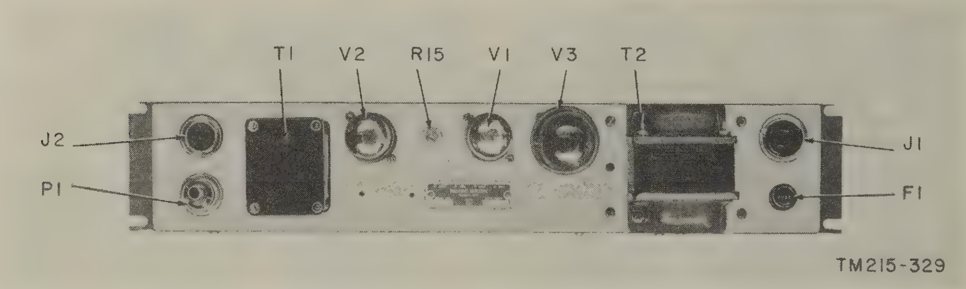


Figure 216. Audio Frequency Oscillator O–373/FRN, rear view.

455. Course Monitor MX–1837/FRN–20 Repair

a. General. The monitor has no unusual repair procedures. Figures 217 through 220 have been provided to assist in parts location. Adjustment data for relays RY1 through RY5 are contained in figure 221 and should be coordinated with procedures given in paragraph 447 as required. Specific instructions for adjustment of relay RY5 are given in *b* below.

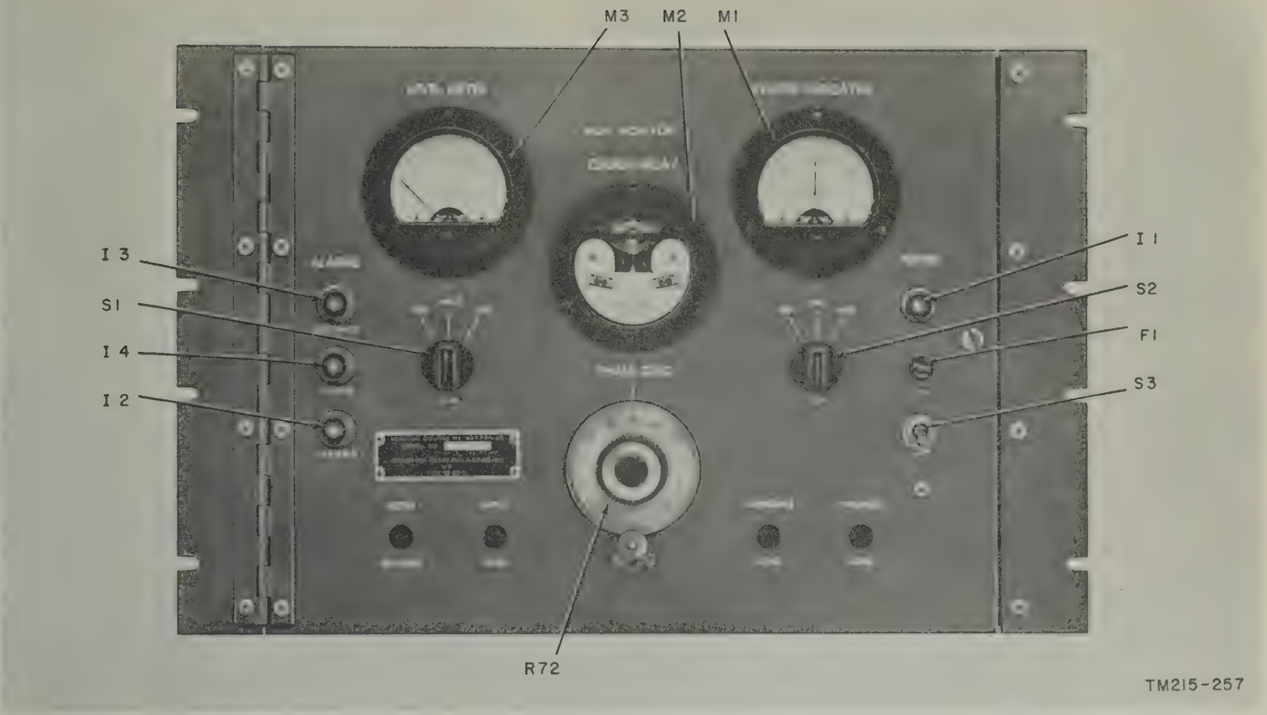


Figure 217. Course Monitor MX-1837/FRN-20, front view.

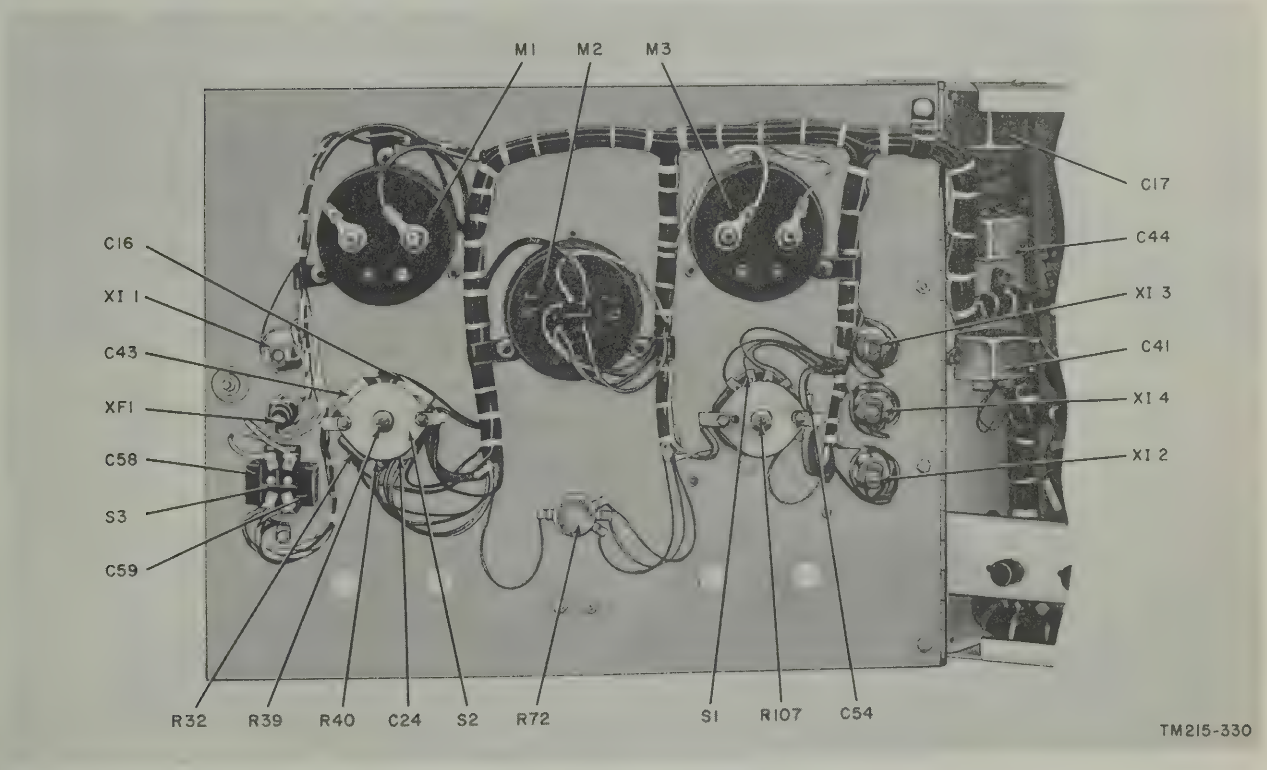


Figure 218. Course Monitor MX-1837/FRN-20 access door rear view.

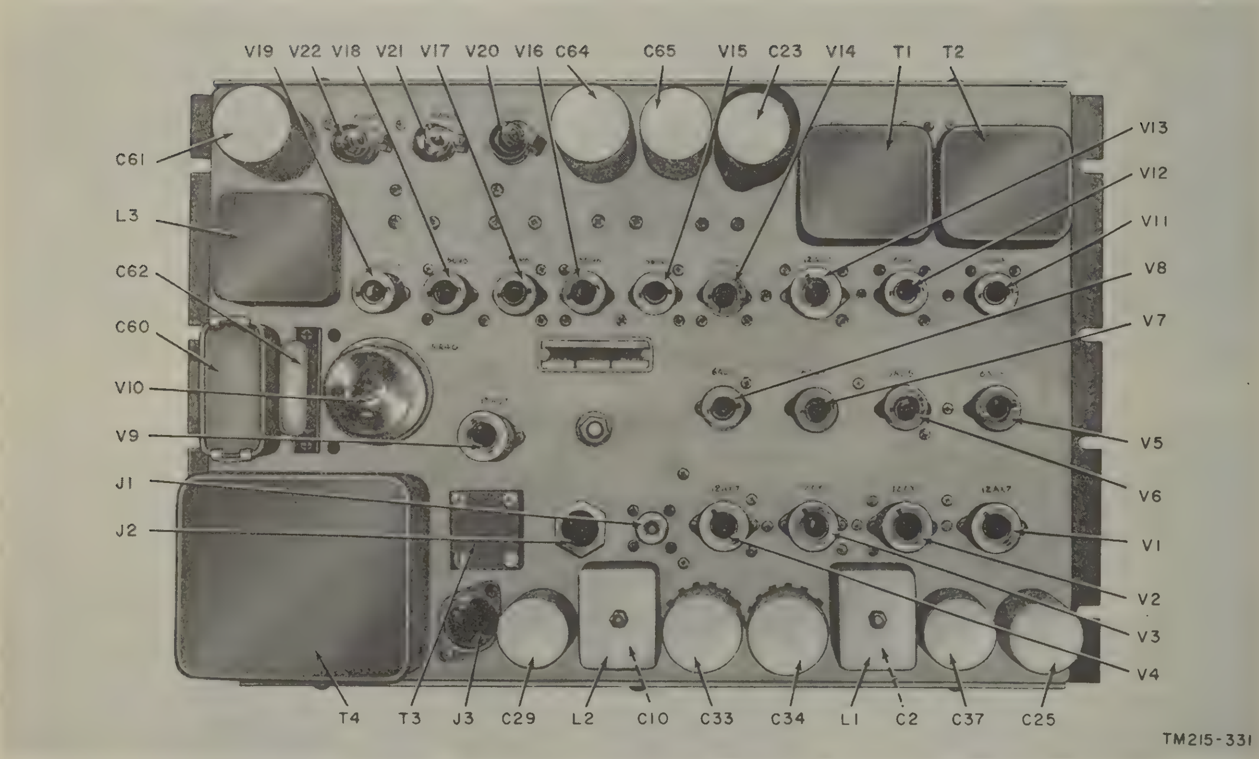


Figure 219. Course Monitor MX–1837/FRN–20, rear view.

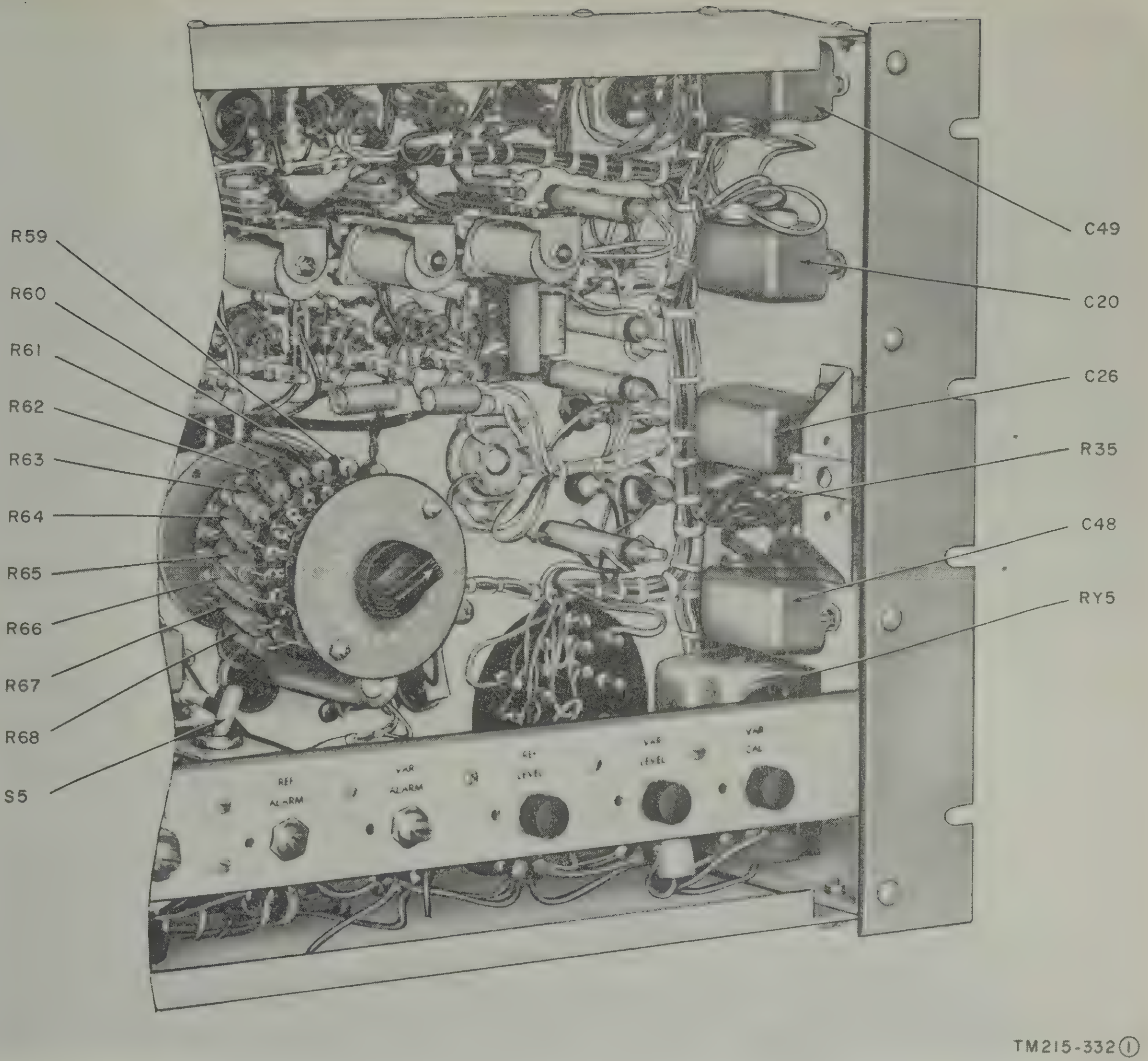


Figure 220. Course Monitor MX–1837/FRN–20, interior view.

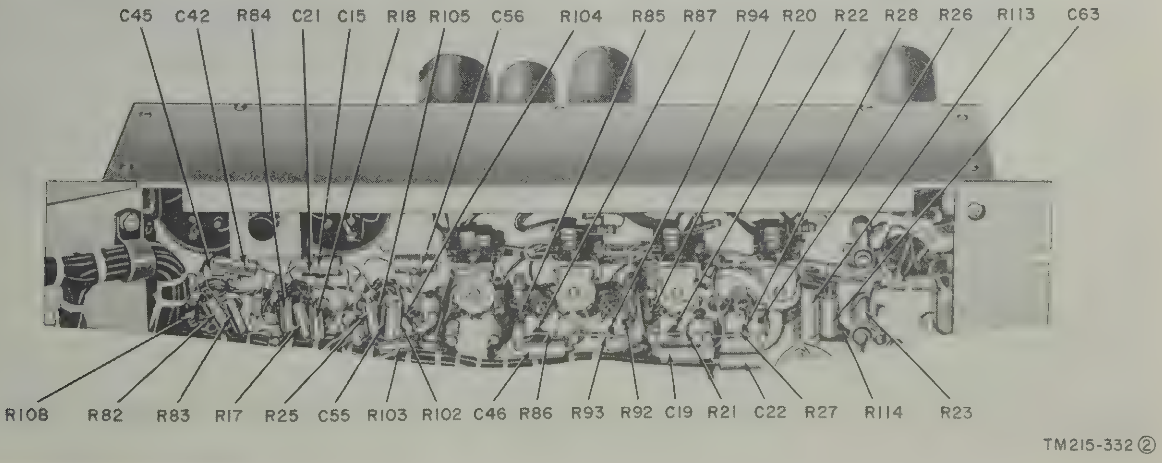


Figure 220—Continued.

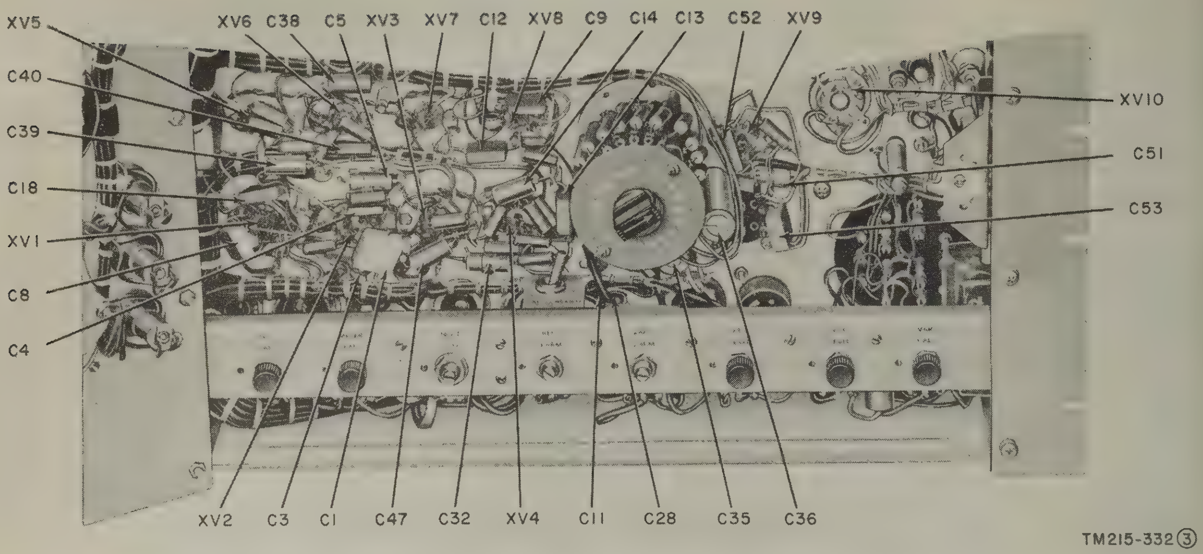


Figure 220—Continued.

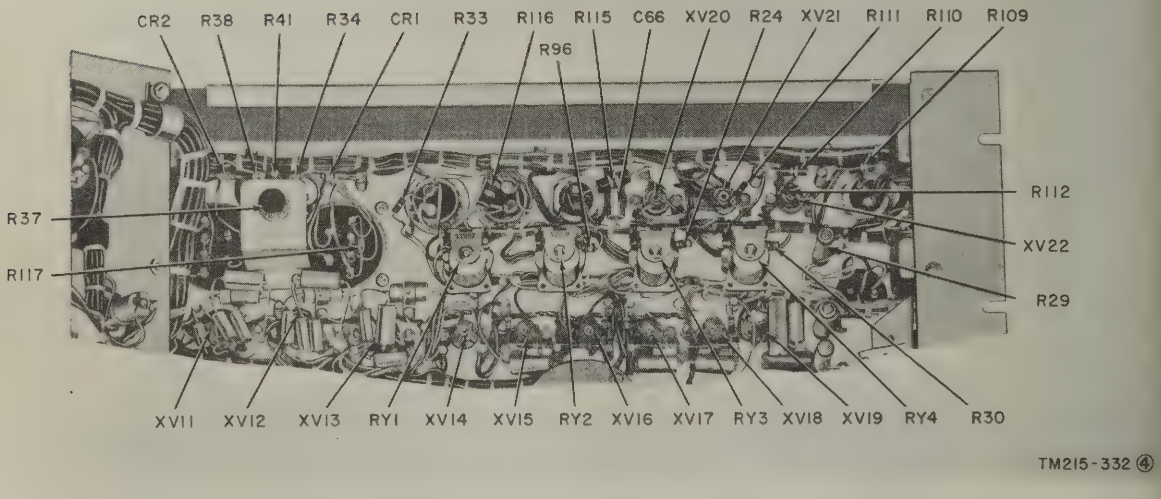


Figure 220—Continued.

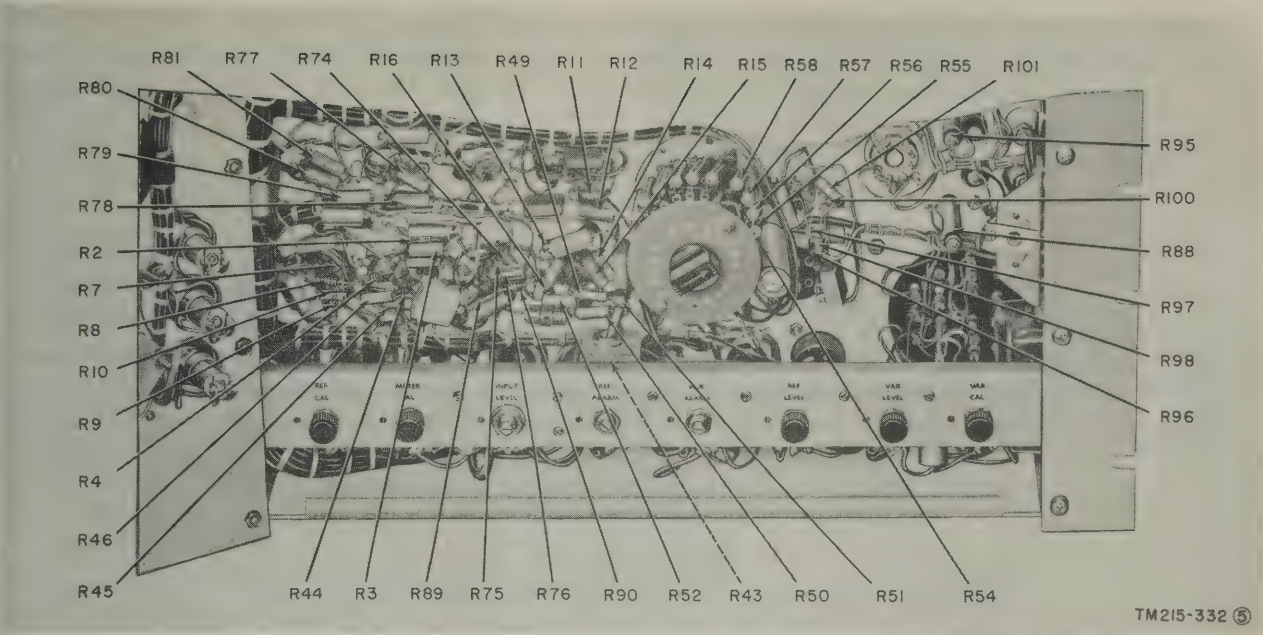


Figure 220—Continued.

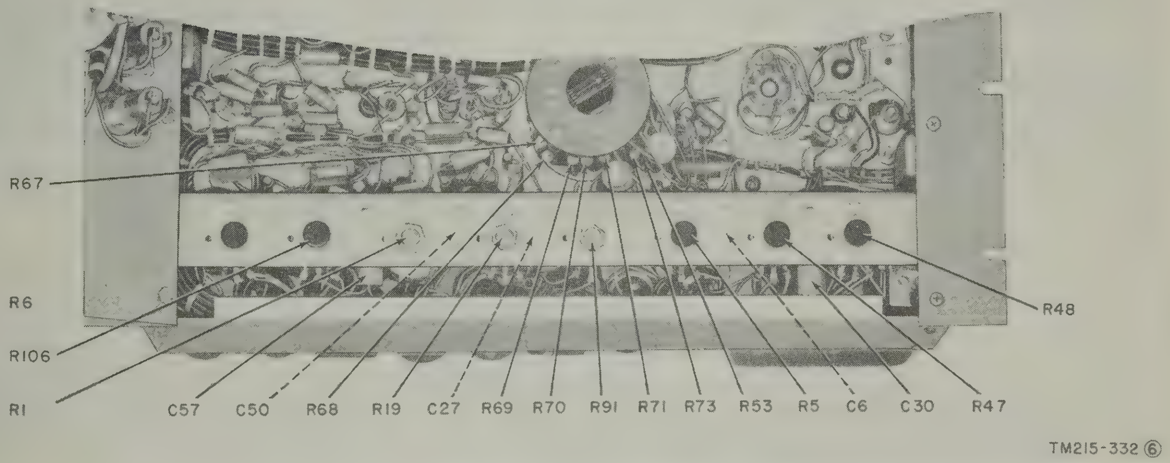


Figure 220—Continued.

b. Relay RY5 Adjustment. Remove the plastic cover from relay RY5 and proceed as follows:

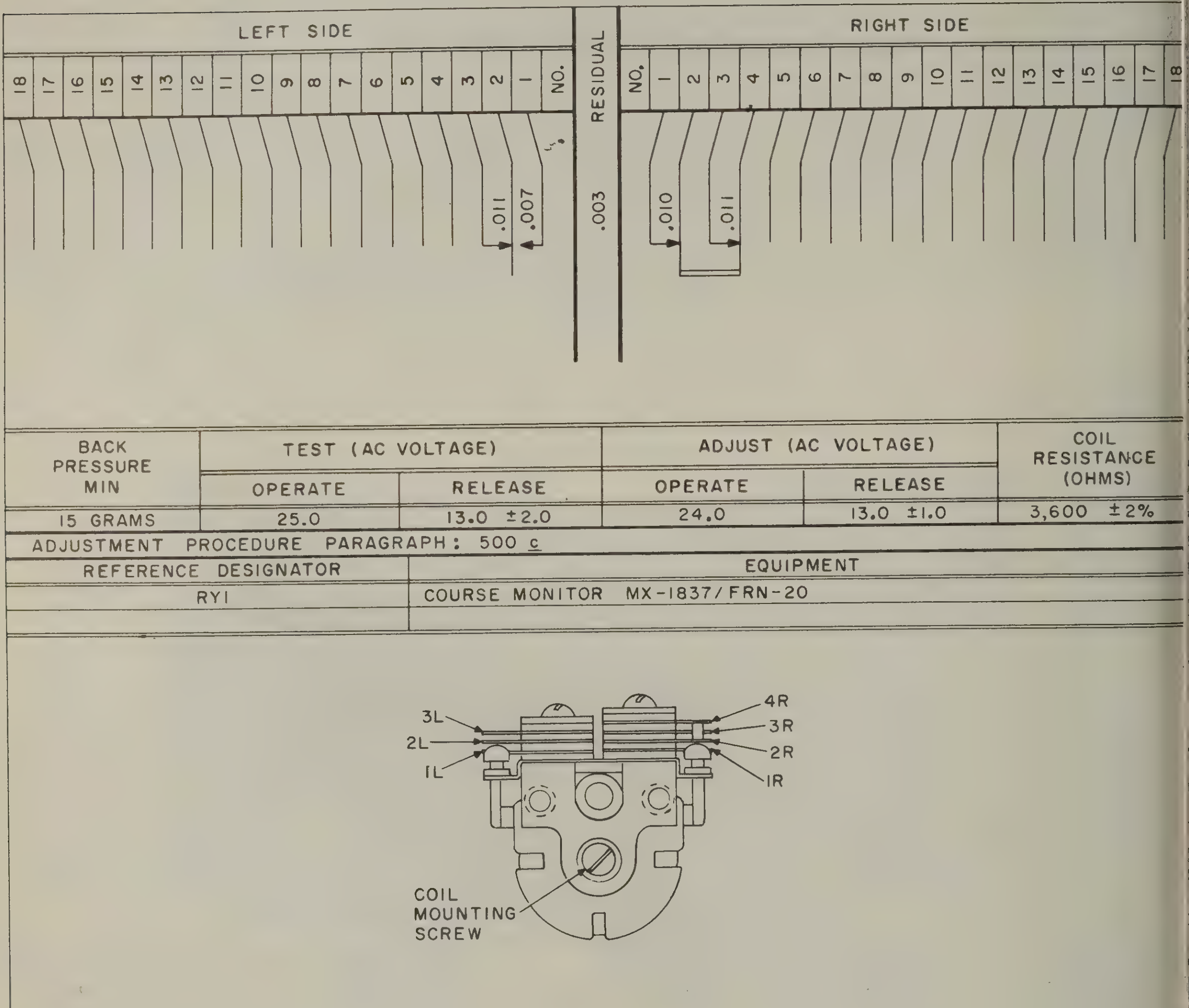
(1) Disconnect one lead to the relay coil and measure the coil dc resistance with the multimeter. Compare the resistance with the chart value in figure 221.

(2) Connect a variable dc voltage source (0 to 12 volts) to the coil of the relay. Slowly increase the voltage until the relay energizes. Compare the voltage with the charted value of figure 221. Adjust the spring tension with the spring adjusting screw to obtain correct pull-in.

(3) Place a 0.002-inch thickness gage between the coil core and the armature and energize the relay with 12 volts dc. Adjust the NO contact screw until the thickness gage is just free to slip out. Lock the contact and recheck the adjustment.

(4) Deenergize the relay and measure the gap between the NO contacts. Adjust the NC contact screw to obtain the 0.015-inch gap specified in the chart of figure 221.

(5) Burnish the contacts lightly with Burnisher TL-557/U as required. Reconnect the relay and install the plastic cover.

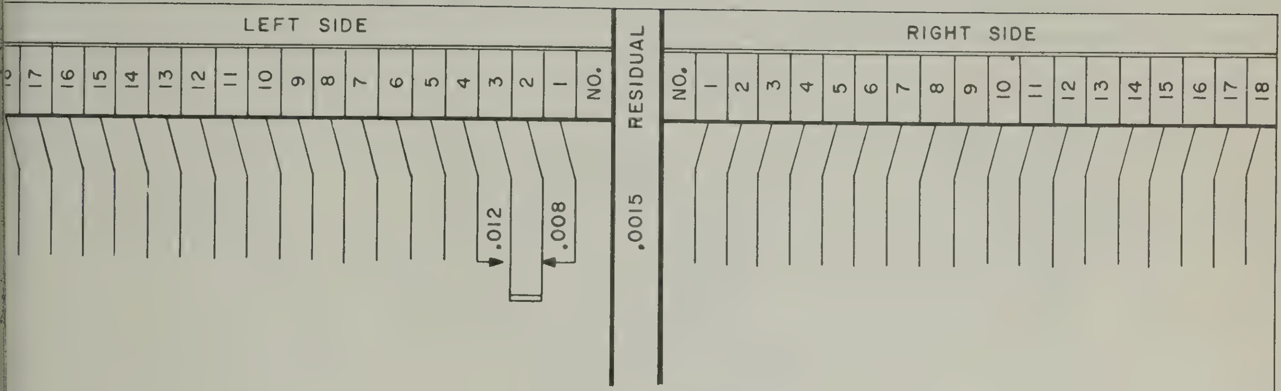


BACK PRESSURE MIN	TEST (AC VOLTAGE)		ADJUST (AC VOLTAGE)		COIL RESISTANCE (OHMS)
	OPERATE	RELEASE	OPERATE	RELEASE	
15 GRAMS	25.0	13.0 ±2.0	24.0	13.0 ±1.0	3,600 ±2%

ADJUSTMENT PROCEDURE PARAGRAPH: 500 c

REFERENCE DESIGNATOR	EQUIPMENT
RY1	COURSE MONITOR MX-1837/FRN-20

Figure 221. Relay adjustment data.



BACK PRESSURE MIN	TEST (AC AMPERES)		ADJUST (AC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
20 GRAMS	.0072	.0055	.0066	.006	3,600 ±2%

ADJUSTMENT PROCEDURE PARAGRAPH: 500 c

REFERENCE DESIGNATOR	EQUIPMENT
RY2, RY3, RY4	COURSE MONITOR MX-1837/FRN-20

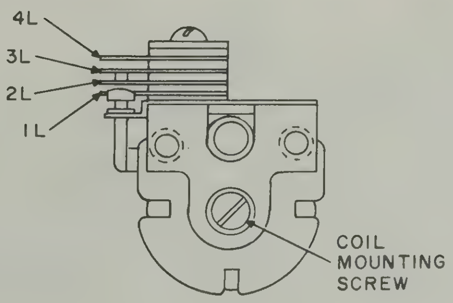


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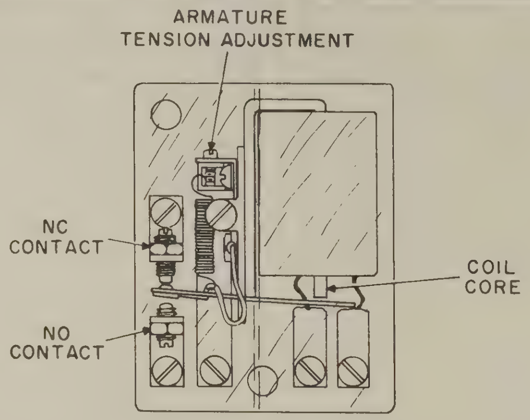
Figure 221—Continued.

ENERGIZED ARMATURE GAP	NO CONTACT GAP	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
.002 INCH	.015 INCH	300 ±2%	5 ±.5V DC

ADJUSTMENT PROCEDURE PARAGRAPH: 455 b

REFERENCE DESIGNATOR	EQUIPMENT
RY5	COURSE MONITOR MX-1837/FRN-20
O 502	RADIO SET CONTROL C-1739/FRN-20



TM215-333③

Figure 221—Continued.

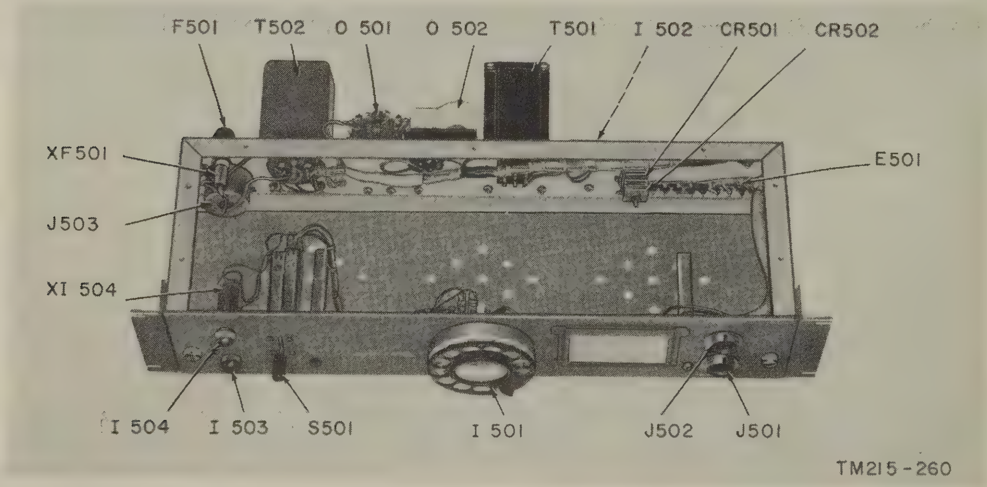


Figure 222. Radio Set Control C–1739/FRN–20, top view.

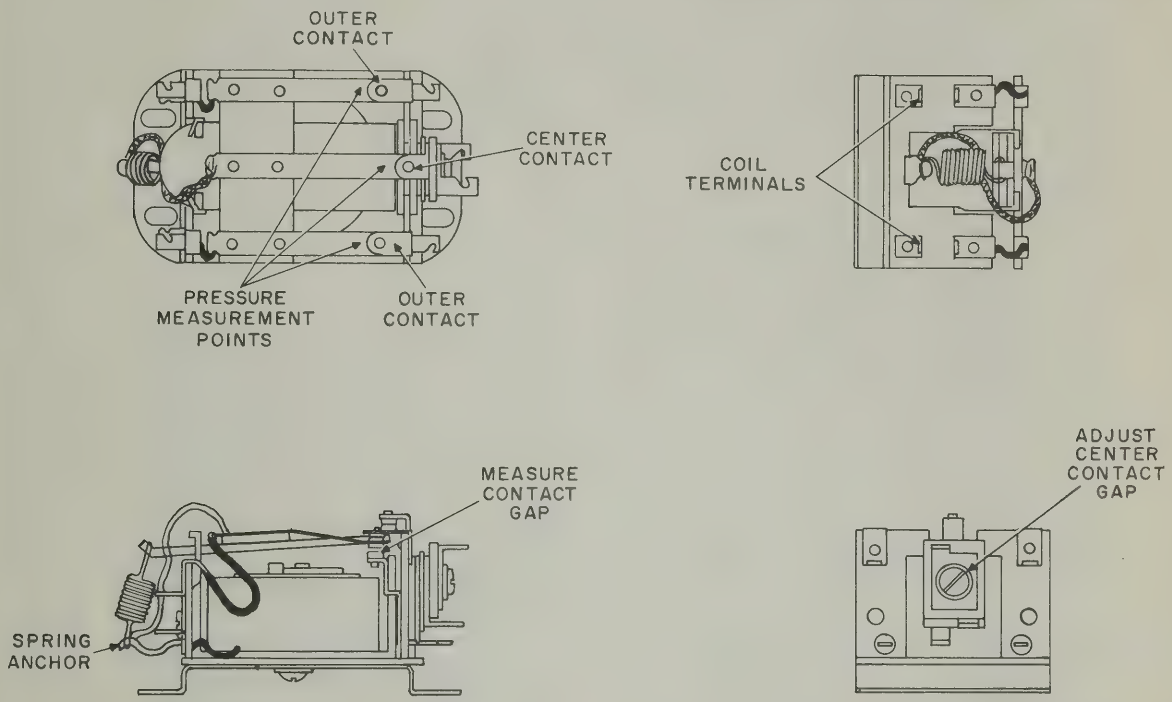
456. Electrical Equipment Cabinet CY–1826/FRN–20 and Radio Set Control C–1739/FRN–20 Repair

No unusual repair procedures are required in the remote control cabinet and the remote control unit. Figure 222 illustrates the parts of the remote control unit. Figure 223 contains the adjustment data for relay O 501 to be used with the procedure given in paragraph 447. Adjustment data for relay O 502 are shown in figure 221 and the procedures are given in paragraph 455*b*. Procedures for adjustment of dial I 501 are contained in TM 11–2103 which applies to the dials and lever switches of the omnirange set. Use figure 224 to aid in locating parts and performing the adjustments described in TM 11–2103.

CONTACT LOCATION	CONTACT GAP MIN	CONTACT OVERTRAVEL MIN	DEENERGIZED PRESSURE MIN	ENERGIZED PRESSURE MIN	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
CENTER	.035 INCH	.005 INCH	10 GRAMS	15 GRAMS	1.8 ± 10%	5.5 ±.5V AC
OUTER	.035 INCH	.005 INCH	10 GRAMS	15 GRAMS		

ADJUSTMENT PROCEDURE PARAGRAPH: 447 b

REFERENCE DESIGNATOR	EQUIPMENT
O 501	RADIO SET CONTROL C-1739/FRN-20



TM215-261

Figure 223. Relay adjustment data.

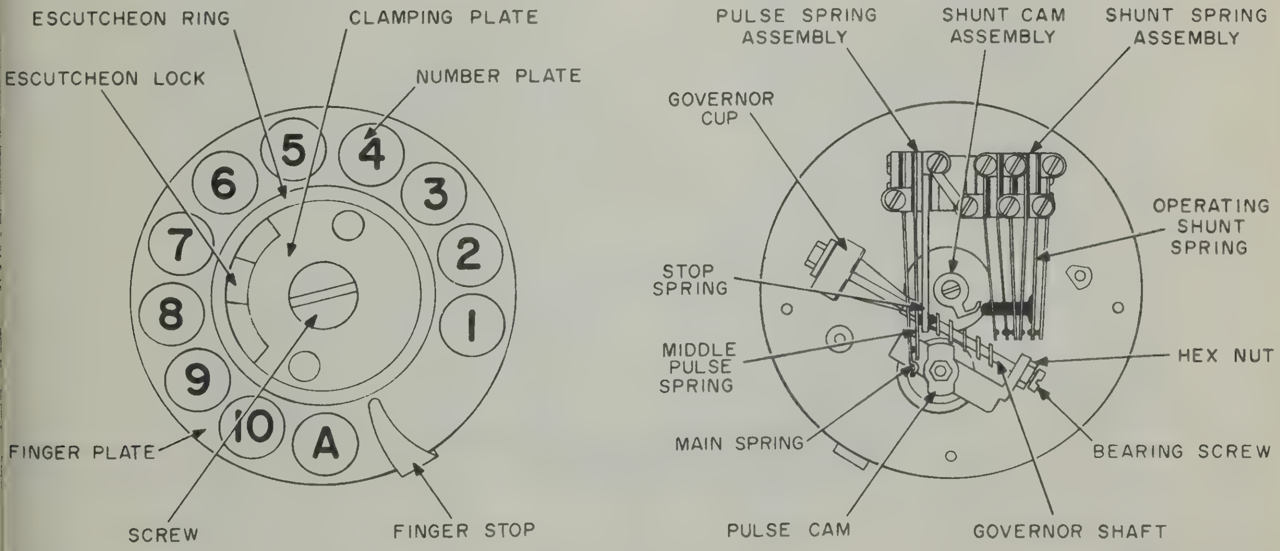


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Figure 224. Telephone dial parts locations.

457. Electrical Equipment Cabinet CY–1897/FRN–22 Repair

No unusual repair procedures are required for the CY–1897/FRN–22. Use figure 225 for part identification during any repairs.

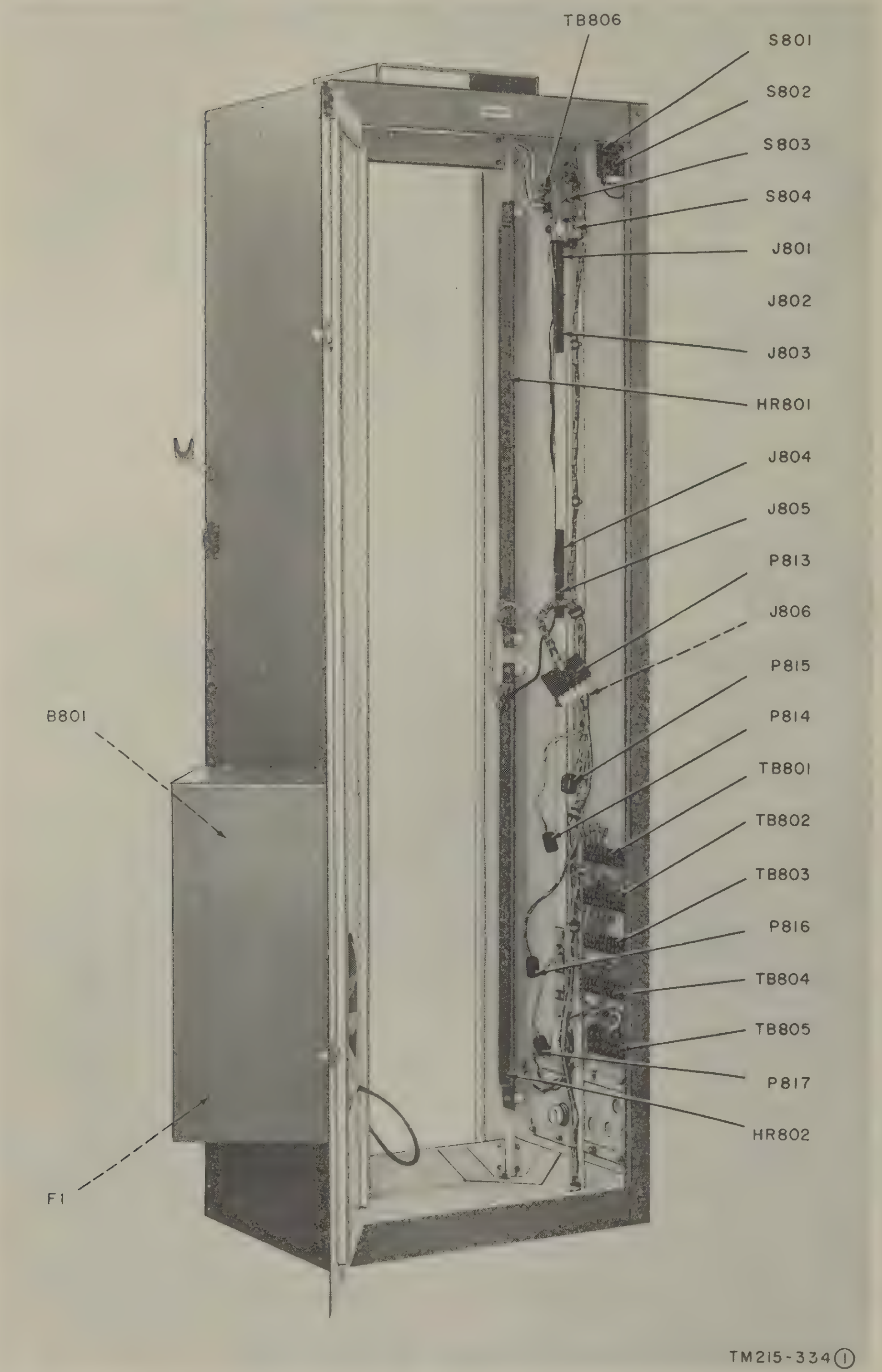

Figure 225. Electrical Equipment Cabinet CY–1897/FRN–22, interior view.

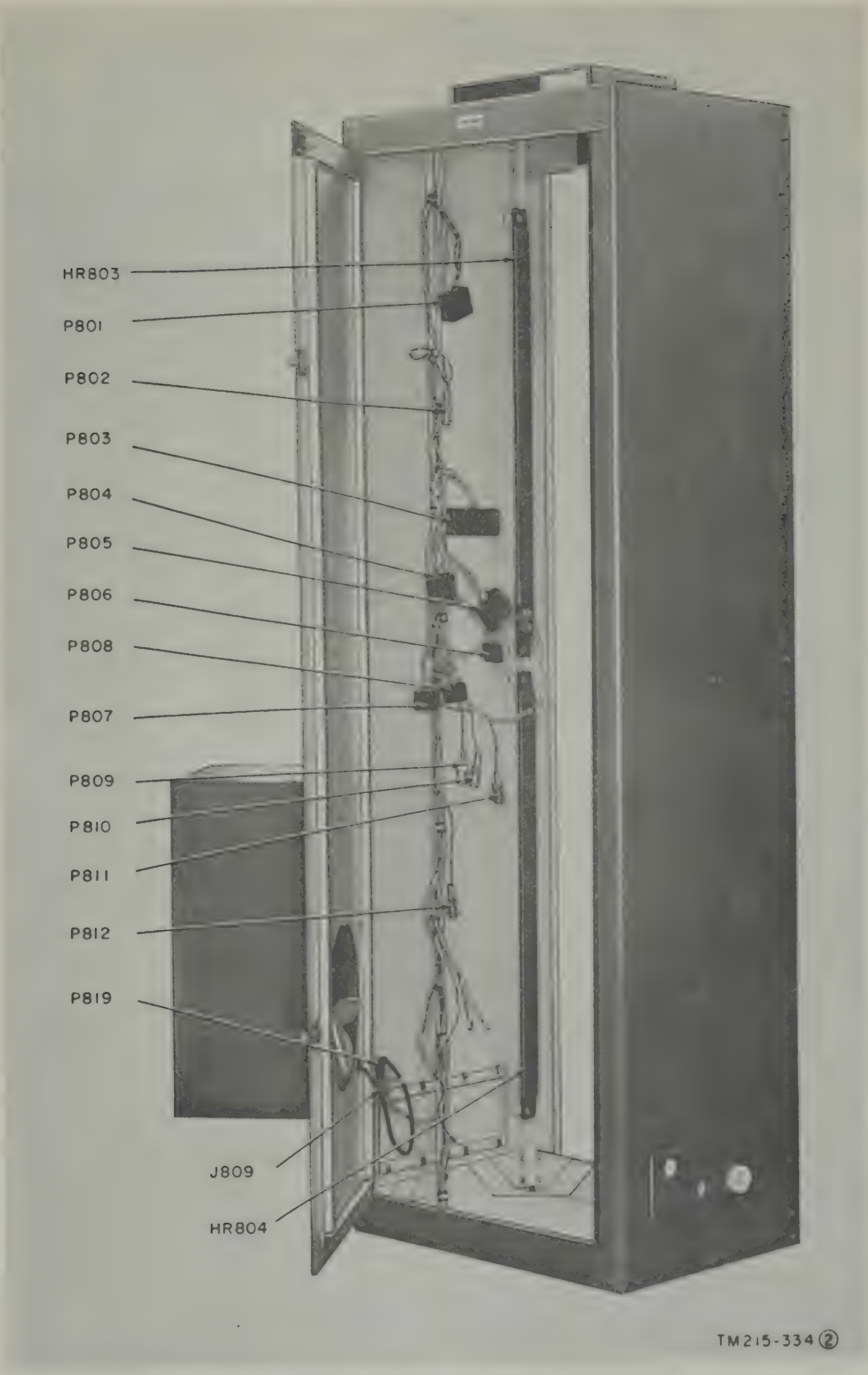

Figure 225—Continued.

458. Electrical Equipment Cabinet CY–1899/FRN–22 Repair

No unusual repair procedures are required for the CY–1899/FRN–22. Use figure 226 for part identification during repairs.

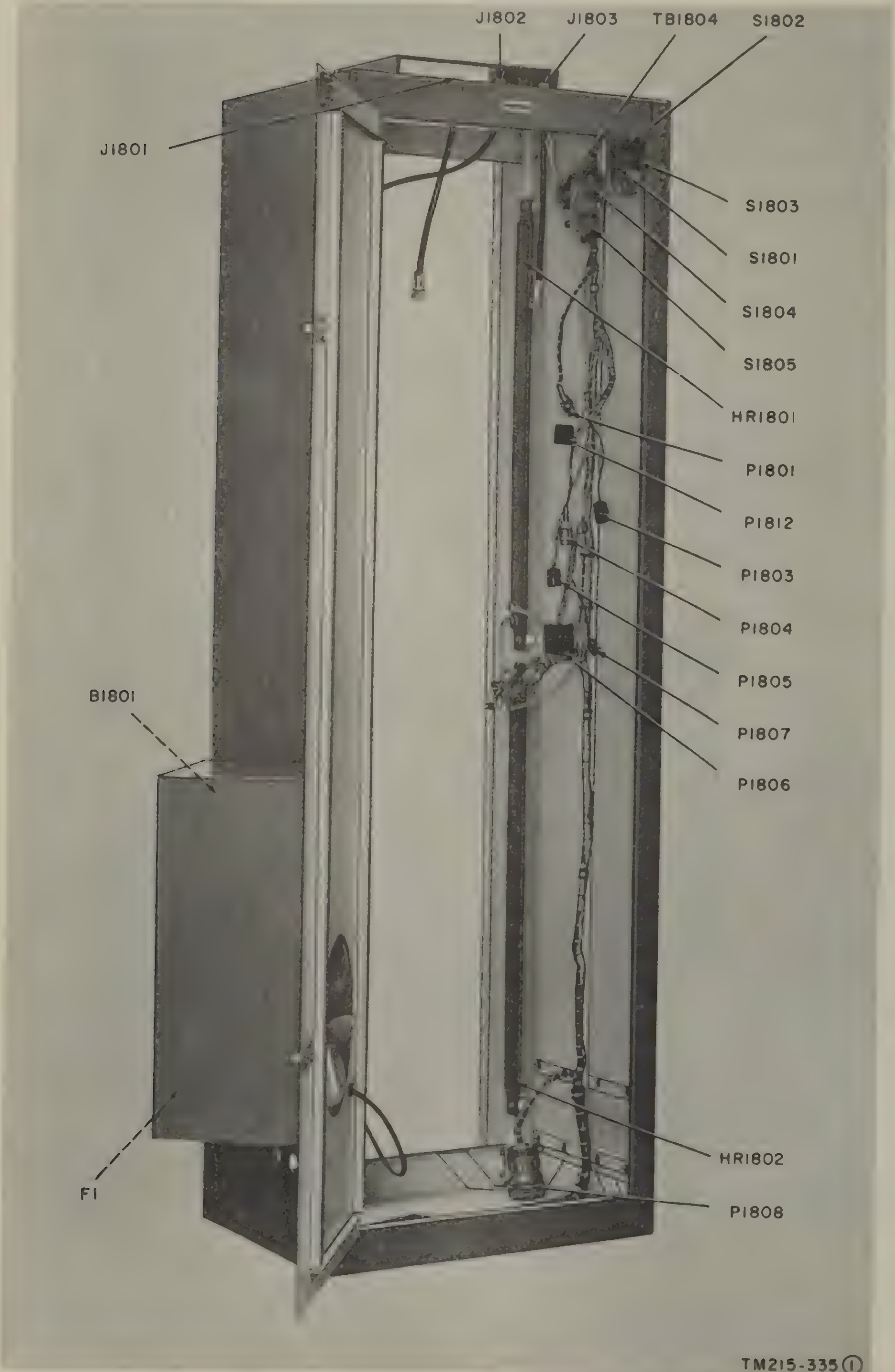

Figure 226. Electrical Equipment Cabinet CY–1899/FRN–22, interior view.

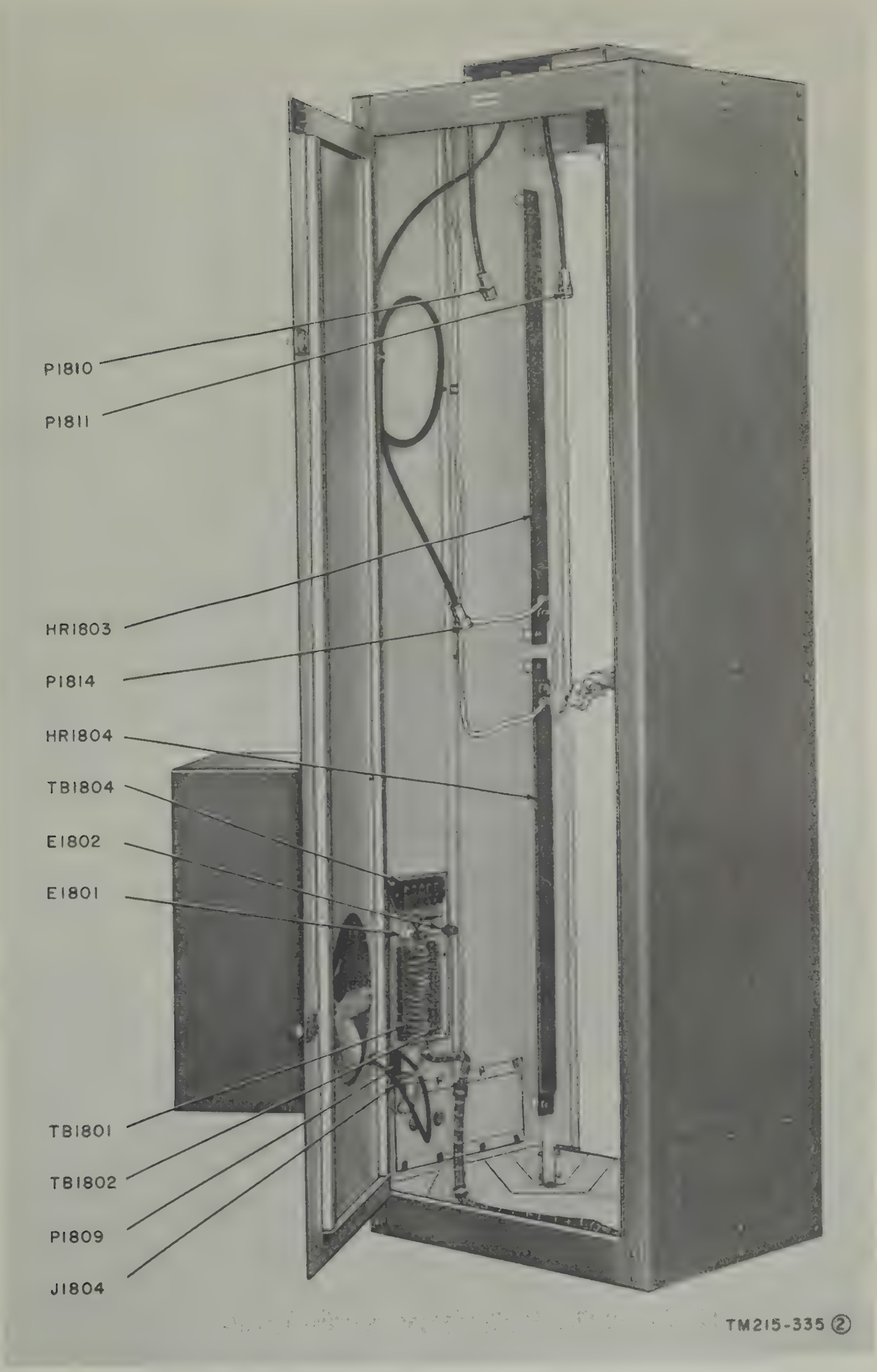

Figure 226—Continued.

459. Electrical Equipment Cabinet CY–2274/FRN–22A Repair

No unusual repair procedures are required for the CY–2274/FRN–22A. Use figure 227 for part identification during repairs.

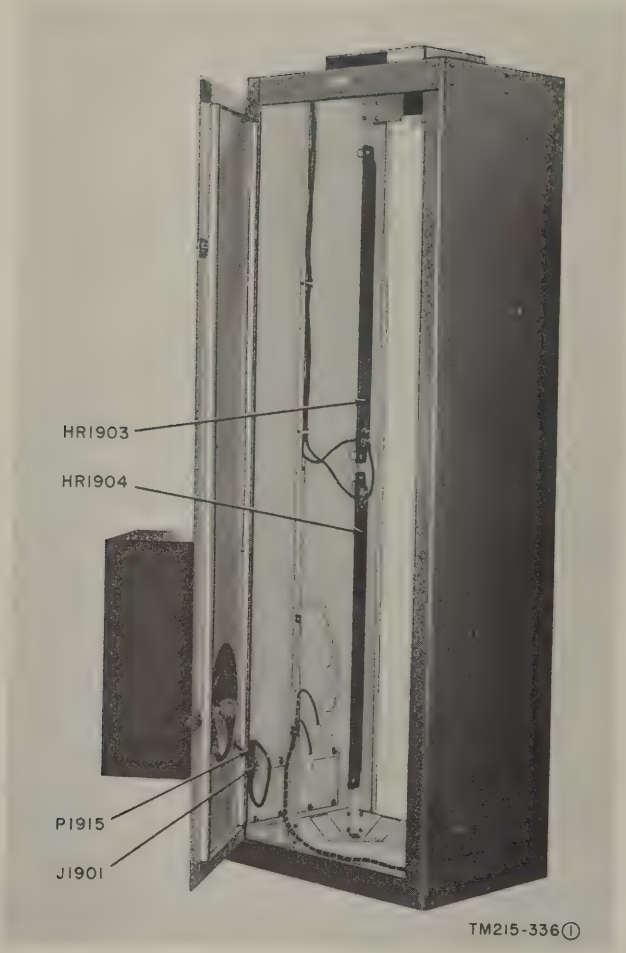

Figure 227. Electrical Equipment Cabinet CY–2274/FRN–22A, interior view.

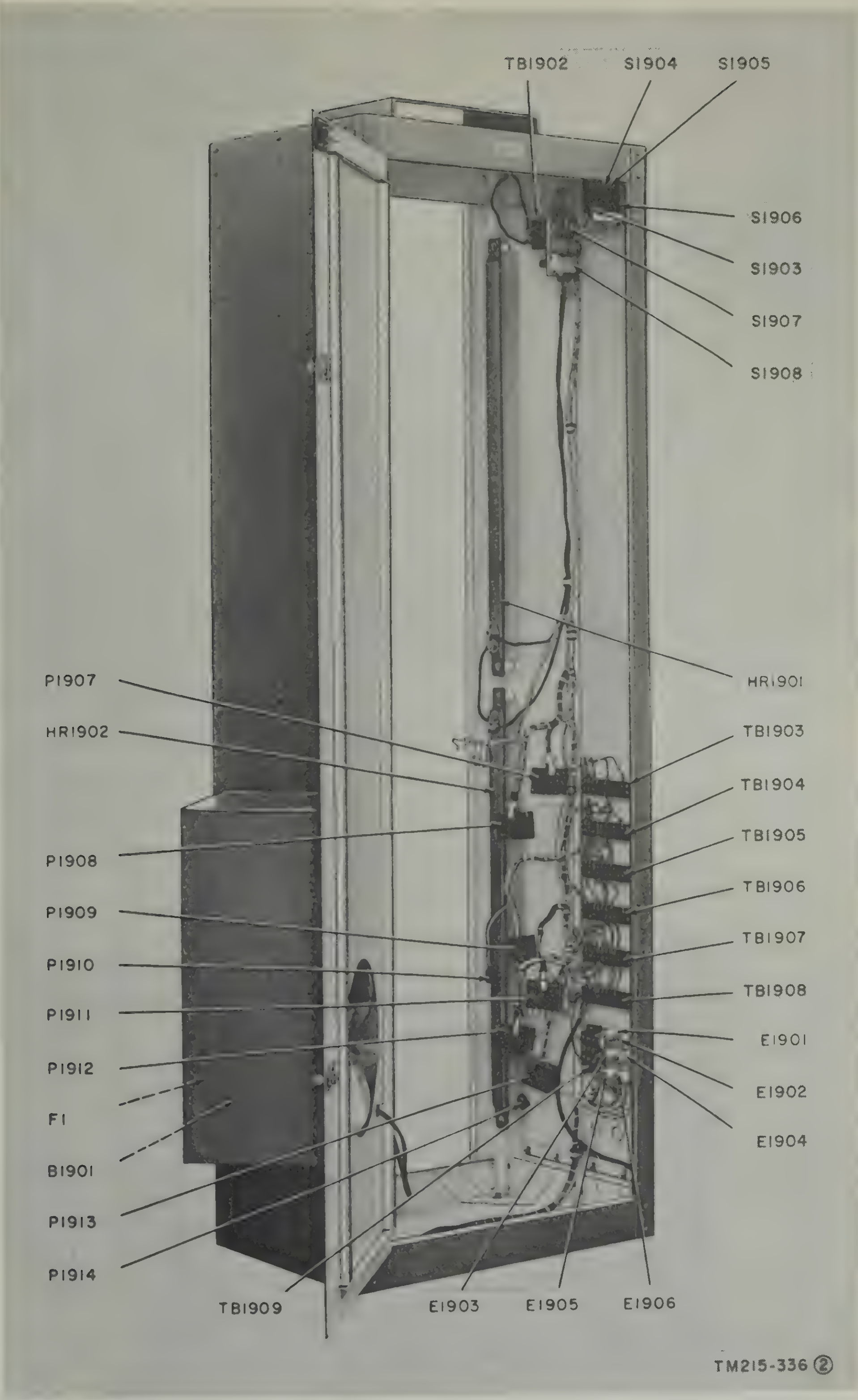

Figure 227—Continued.

460. Electrical Goniometer GO–12/FRN–20 Repair

(figs. 228–231)

a. General. Repairs to the goniometer generally require no special procedures and are limited to parts replacements. Figures 228 through 231 will assist in parts identification. Subparagraphs *b* and *c* below contain specific instructions for replacement of the baluns and goniometer capacitor. Do not attempt any individual repairs on the baluns or goniometer capacitor.

b. Balun Replacements.

(1) *Removal.* Refer to figure 231, contained in separate envelope, and remove the attaching parts that fasten the chassis receptacle (J3, J4, or J5). Remove the six screws that fasten the goniometer capacitor cover. (First remove the plastic cover and dial lock assembly on goniometer with serial numbers 614 and above.) Unsolder the balun connections at capacitor C17. Remove the nuts that fasten the balun to the capacitor housing and remove the balun.

(2) *Installation.* Form the new balun by hand to match the one removed. Do not use tools which will tend to kink-damage the replacement balun. The material used is soft and easily formed by hand pressure alone. Slip the balun into the capacitor housing and place the nut on fingertight. Install the chassis end in the chassis and fasten it with the four sets of attaching parts. Form the balun to avoid touching other parts and tighten the nut at the capacitor. Reconnect the leads and reinstall the cover plate.

c. Capacitor Replacement.

(1) *Removal.* Remove the cover plate from the capacitor housing, unsolder the leads from all baluns, and disconnect plug P1. Remove the drive belt and balun attaching nuts. Refer to figure 229 and remove the six capacitor holddown screws. Lift the capacitor away from the baluns.

(2) *Installation.* Slip the baluns into the side of the capacitor housing; fasten the ca-

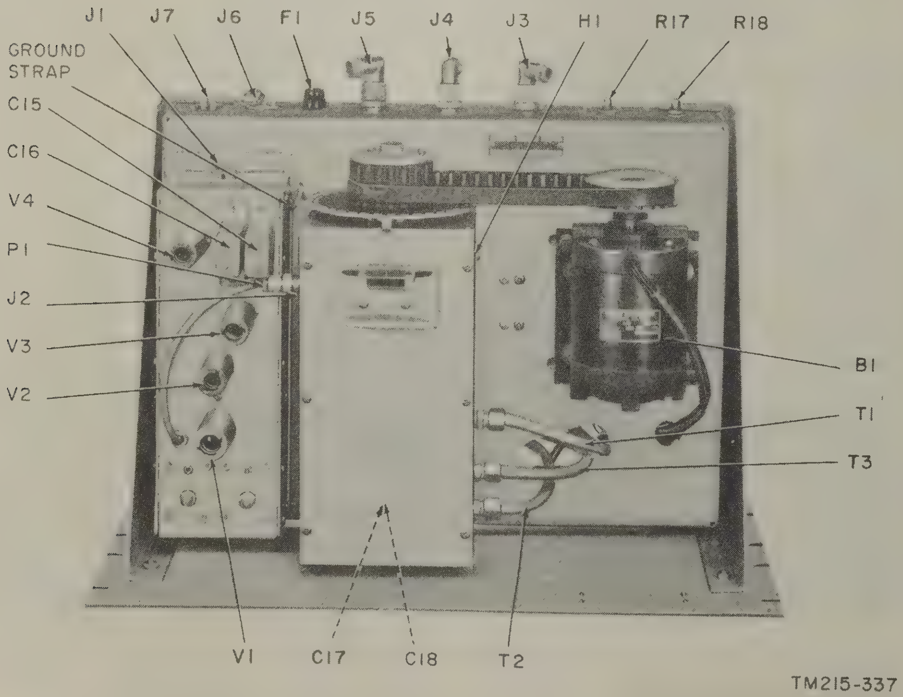

Figure 228. Electrical Goniometer GO–12/FRN–20, top view.

pacitor with the six screws and tighten them. (Be sure that the capacitor pulley is in line with the motor pulley.) Secure the baluns with nuts and solder the leads to capacitor C17. Connect plug P1 and reinstall the cover plate. Install the drive belt and adjust it in accordance with instructions given in paragraph 446.

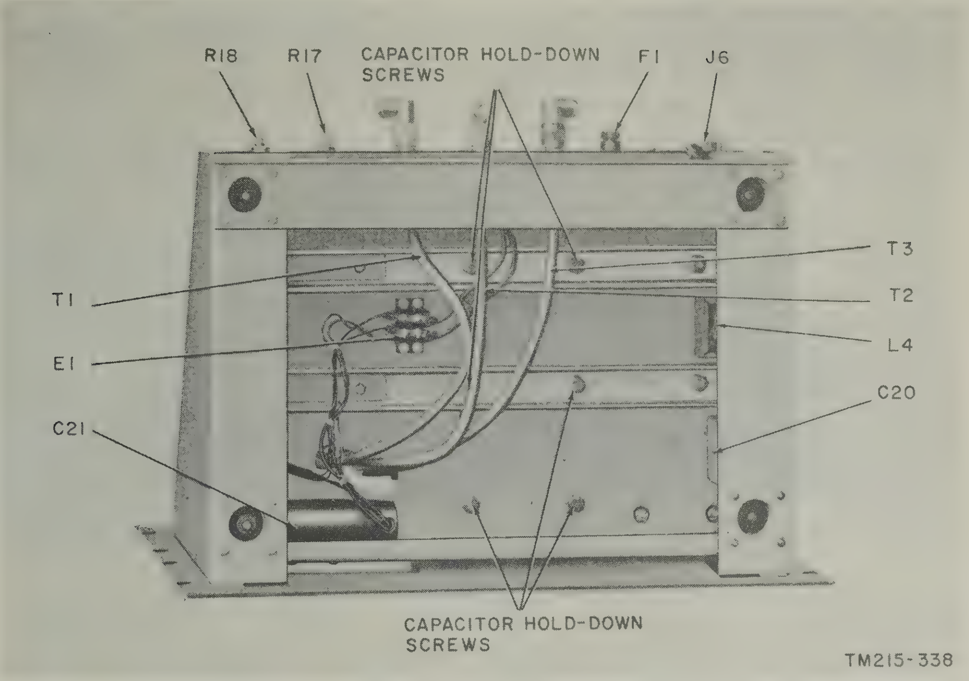

Figure 229. Electrical Goniometer GO–12/FRN–20, bottom view.

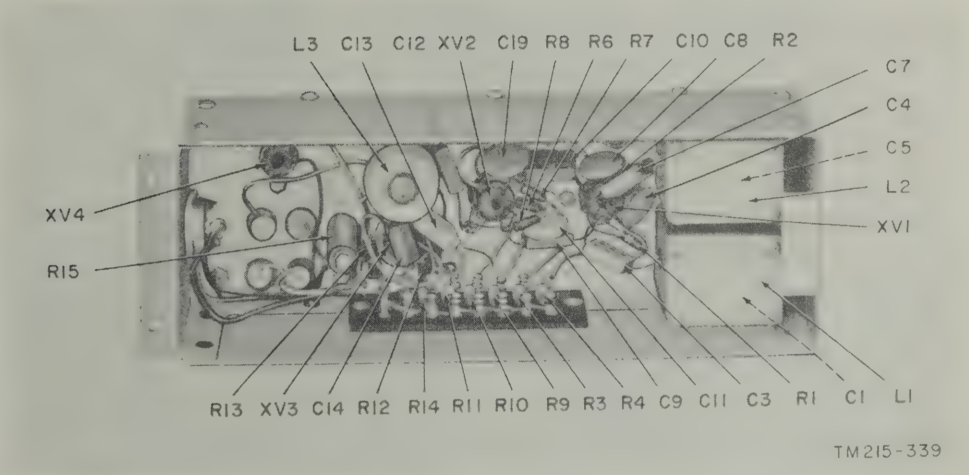

Figure 230. Electrical Goniometer GO–12/FRN–20, subchassis interior view.

461. Indicator Panel SB–830/FRN–22A Repair

No unusual repair procedures are required for the meter panel. When meters and switches are to be replaced, refer to figures 232 and 233 to identify the parts.

462. Keyer KY–175/FRN Repair

a. General. No unusual repair procedures are required in the keyer. Figures 234, 235, and 236 are provided to assist in parts identification and the location of fastening devices. Details for replacing and coding the keyer and cycle wheels are contained in paragraph 42. Adjustment of switches S501 and S502 is given in *b* below.

b. Switch S501 and S502 Adjustment. The instructions and dimensions given in the following steps apply to either switch.

(1) Rotate the keyer wheels, electrically or manually, until the switch roller drops into a breakout. The roller should just touch or have a maximum clearance of 0.006 inch.

(2) Measure the pressure required to just break the contacts which closed in (1) above. (Use Gram Gauge TL–559/U.)

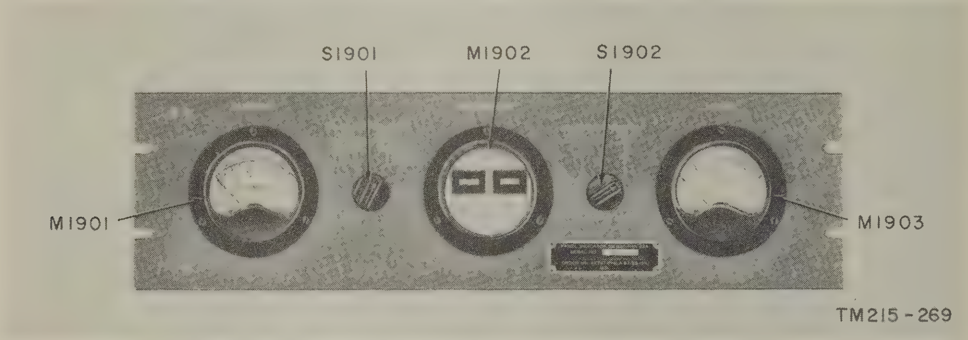

Figure 232. Indicator Panel SB–830/FRN–22A, front view.

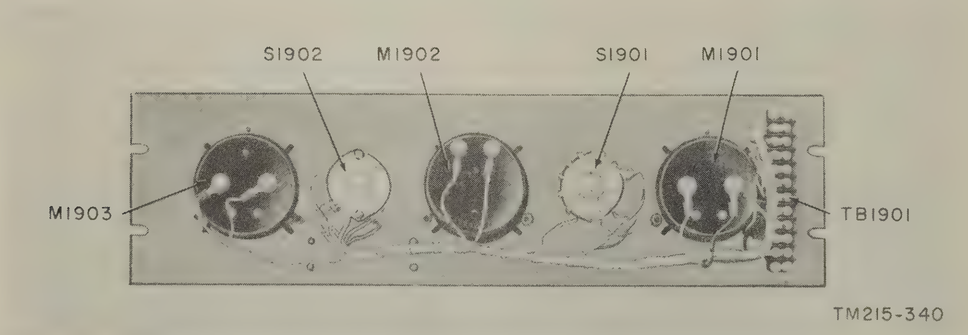

Figure 233. Indicator Panel SB–830/FRN–22A, rear view.

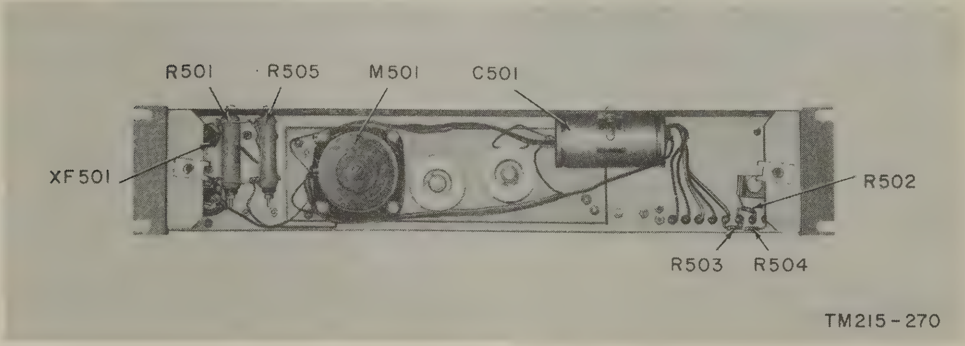

Figure 234. Keyer KY–175/FRN, interior view.

Adjust the roller arm and the contact to 30 grams pressure by bending both arms until the pressure and roller clearance are correct. The roller arm should be straight between the contact and the roller.

(3) Measure the gap of the open contacts ((1) above) and adjust by bending the open contact arm to obtain a gap of 0.016 ±0.002 inch.

(4) Rotate the keyer wheels until the roller is out of the breakout and check the pressure required to just break the contacts. (Use Gram Gauge TL–559/U.) The minimum pressure should be 30 grams. The contact gap of the contacts just opened should be 0.016 ±0.002 inch.

(5) Recheck and adjust the code and cycle wheels as instructed in paragraph 42, after adjusting the switches.

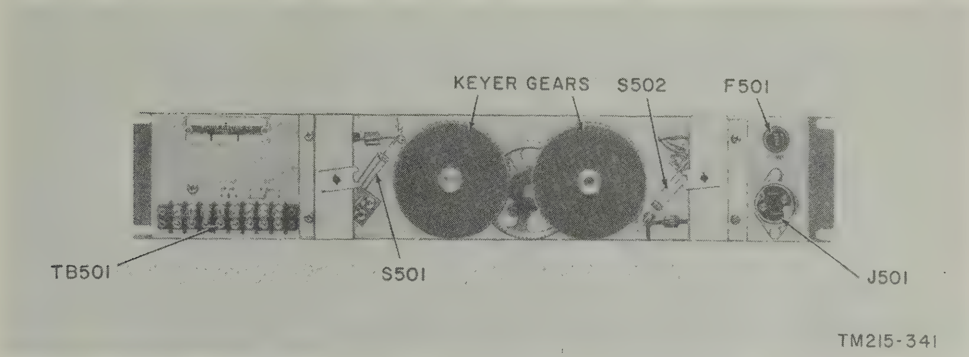

Figure 235. Keyer KY–175/FRN, rear view.

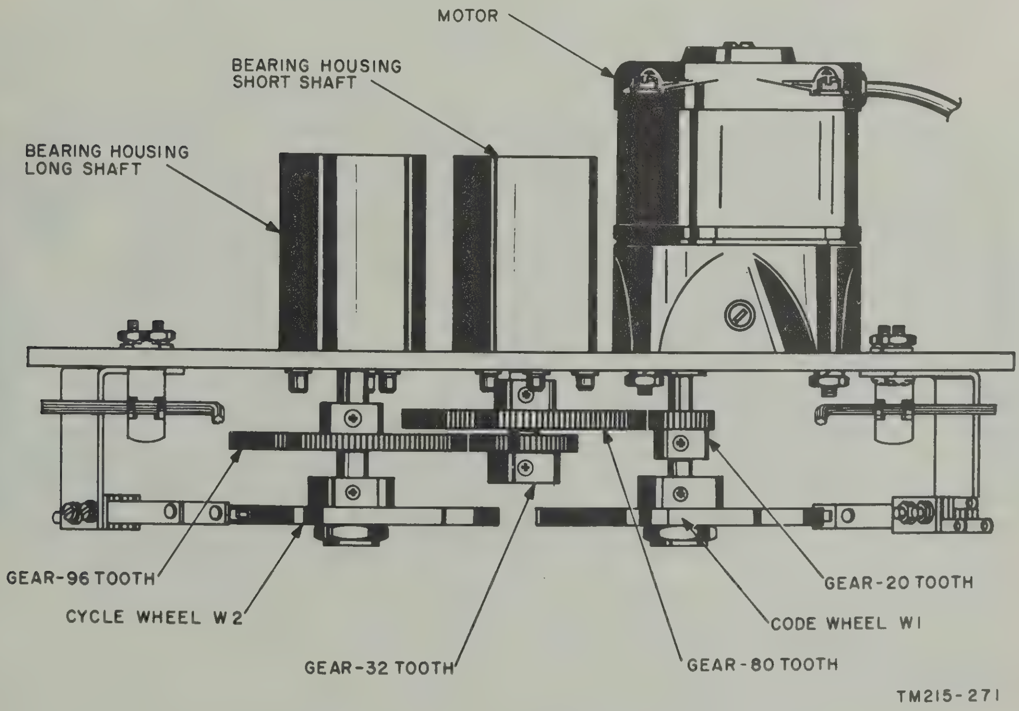

Figure 236. Keyer KY–175/FRN, disk and switch adjustments.

463. Modulation Eliminator MX–1843/FRN–20 Repair

No unusual repair procedures are required in the modulation eliminator. Figures 237 and 238 will assist in parts identification; adjustment procedures are contained in paragraph 46. Refer to figure 221 and paragraph 447 for data and detailed instructions for repairs to relay K1.

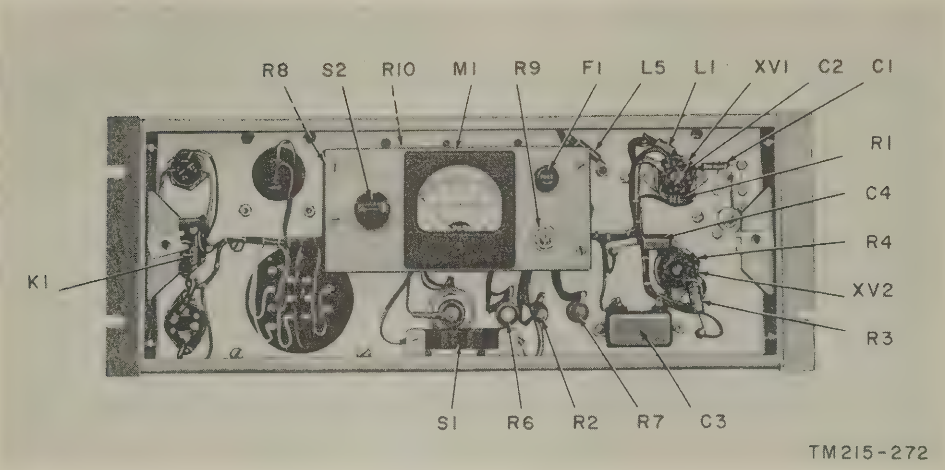

Figure 237. Modulation Eliminator MX–1843/FRN–20, interior view.

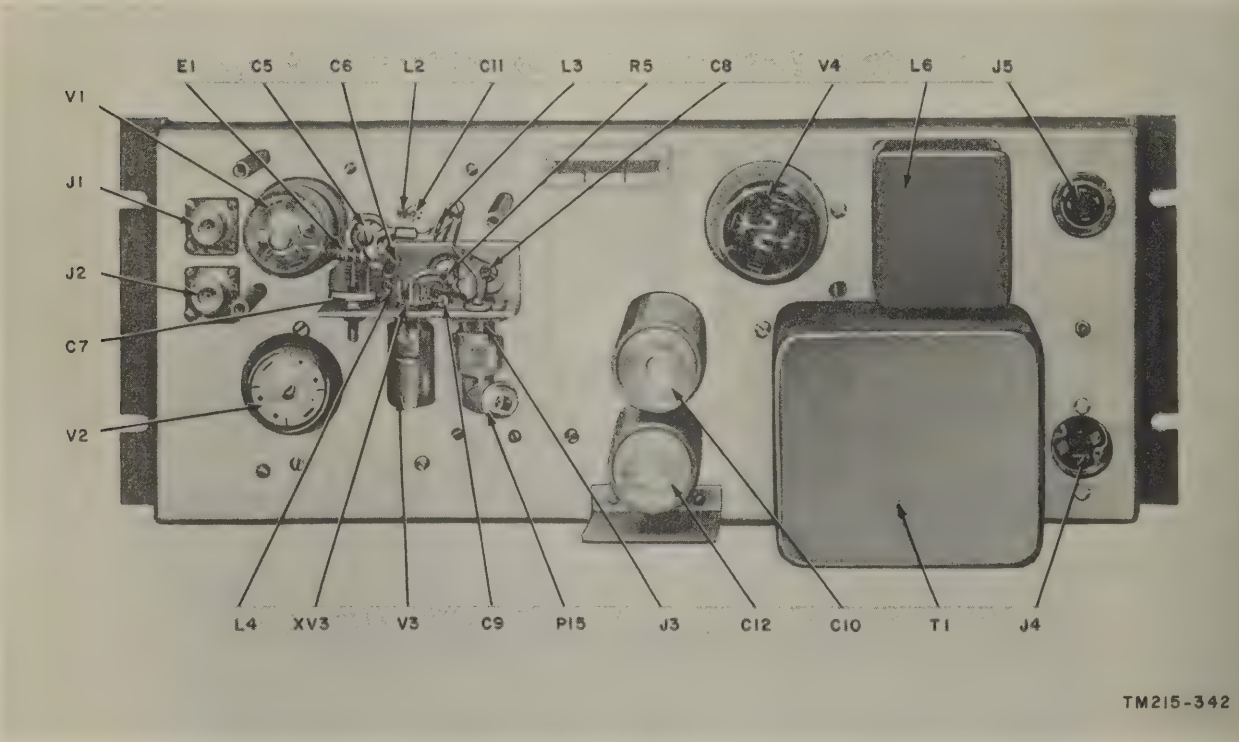

Figure 238. Modulation Eliminator MX–1834/FRN–20, rear view.

464. Power Supply PP–1329/FRN–20 Repair

Repairs to the PP–1329/FRN–20 consist of parts replacement and adjustment of relays K1401 and K1402. Figures 239 and 240 provide parts identification and location information. Use figure 241 and the procedures given in paragraph 447 for adjustments of the relays.

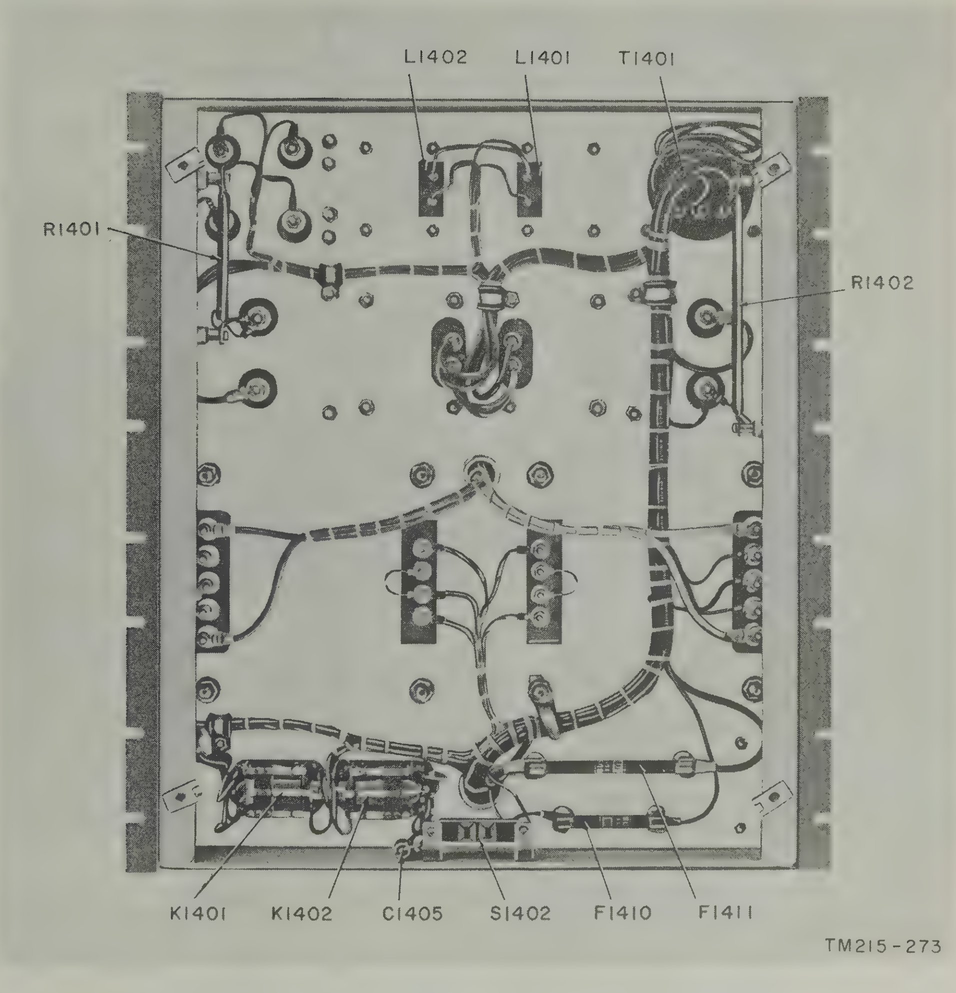

Figure 239. Power Supply PP–1329/FRN–20, interior view.

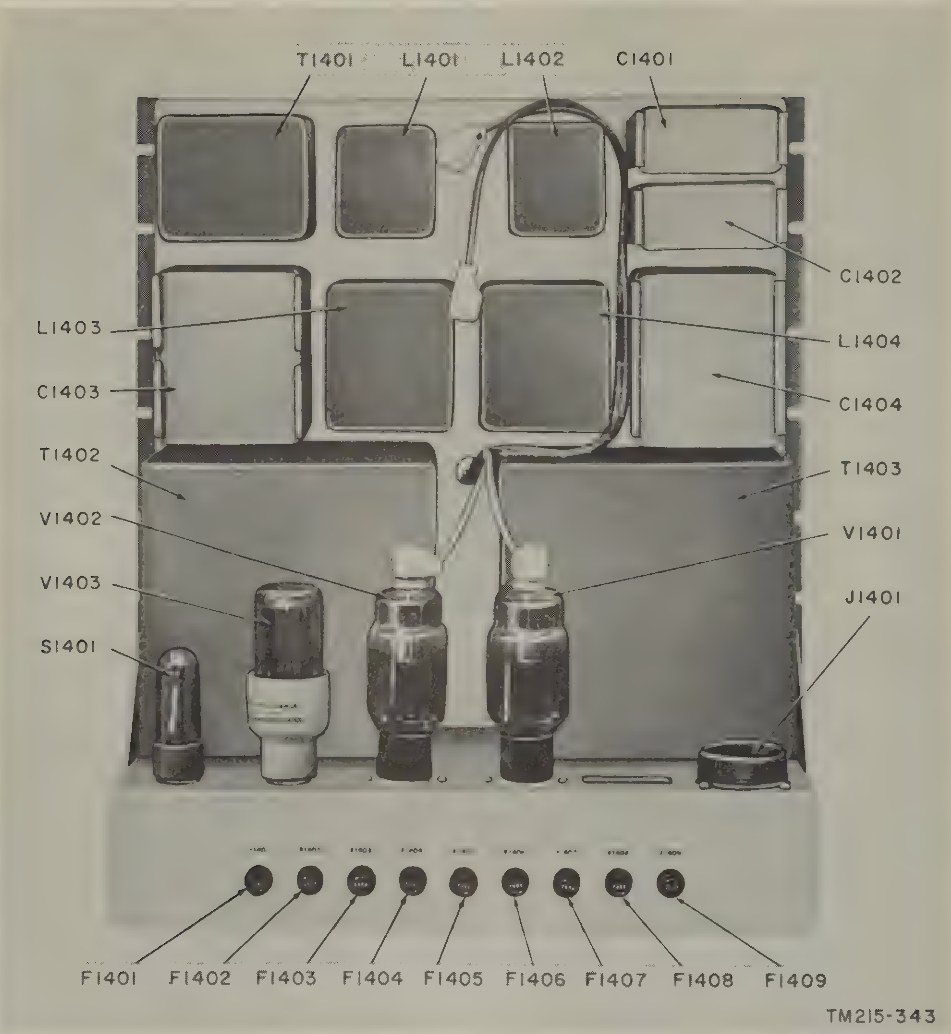

Figure 240. Power Supply PP–1329/FRN–20, rear view.

CONTACT LOCATION	CONTACT GAP MIN	CONTACT OVERTRAVEL MIN	DEENERGIZED PRESSURE MIN	ENERGIZED PRESSURE MIN	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
CENTER	.030 INCH	.008 INCH	5 GRAMS	7 GRAMS	600 ±10%	80-95V AC
OUTER	.030 INCH	.008 INCH	20 GRAMS	20 GRAMS		
ADJUSTMENT PROCEDURE PARAGRAPH: 447 b						

REFERENCE DESIGNATOR	EQUIPMENT
K1401 K1402	POWER SUPPLY PP-1329/FRN-20

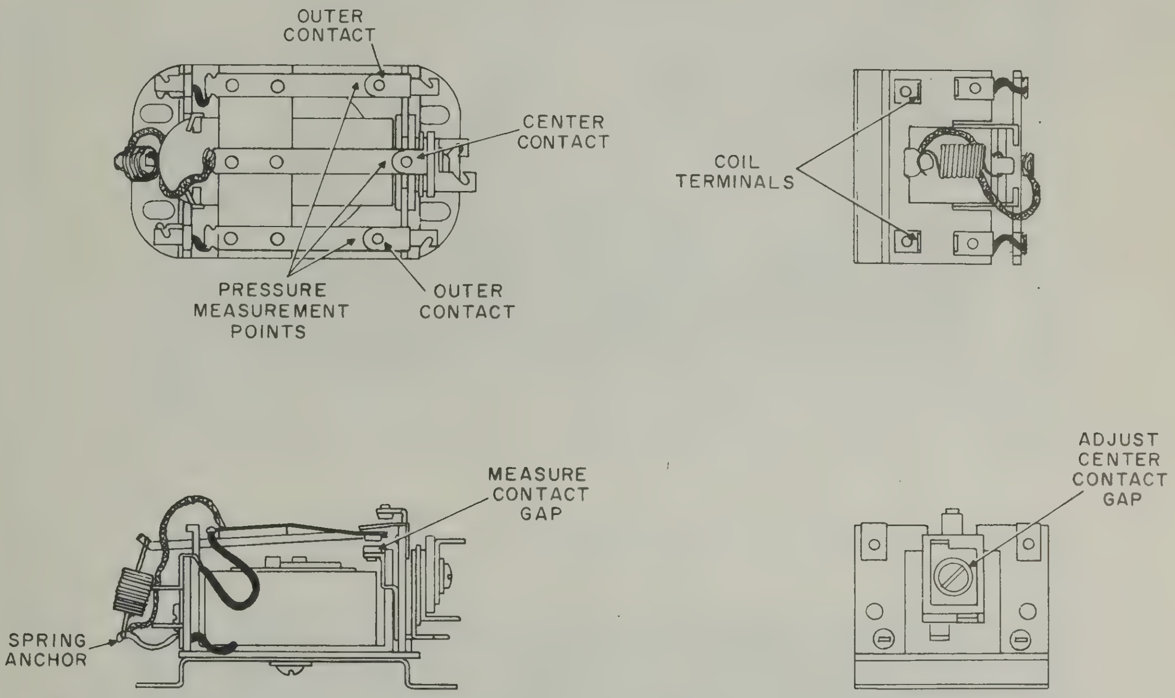

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Figure 241. Relay adjustment data.

465. Power Supply PP-1331/FRN-20 Repair

Repairs to the PP-1331/FRN-20 consist of parts replacement and adjustment of relays S4 and S5. Figures 242 and 243 provide parts identification and location information. Use figure 208 and the procedure given in paragraph 447 for adjustment of the relays.

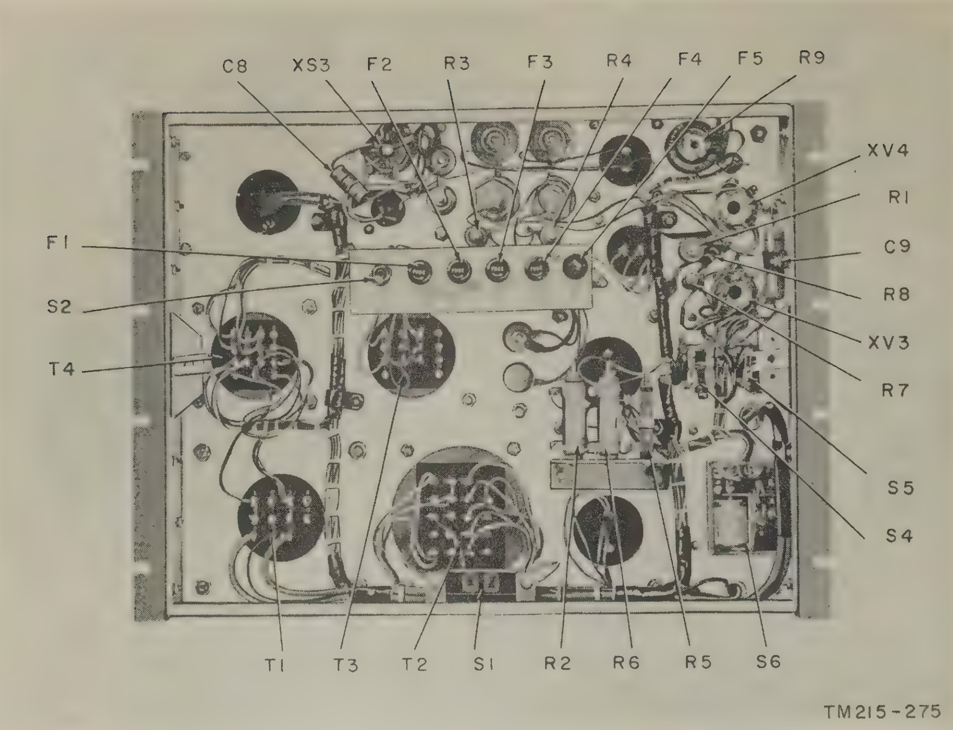


Figure 242. Power Supply PP–1331/FRN–20, interior view.

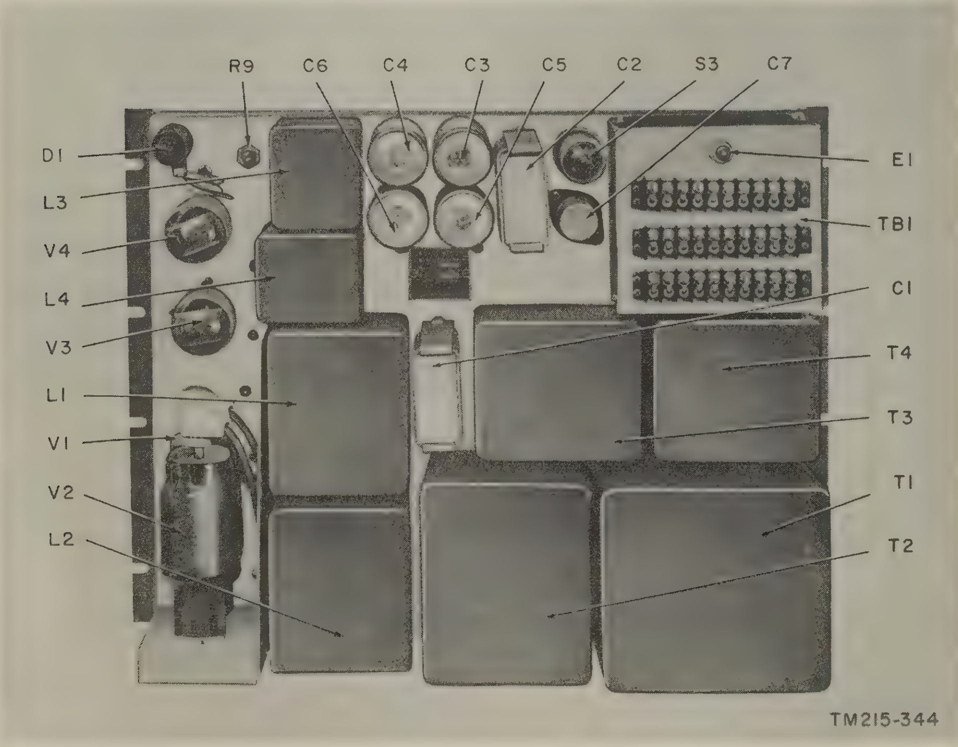


Figure 243. Power Supply PP–1331/FRN–20, rear view.

466. Power Supply PP-1415/FRN-22 Repair

No special repair procedures are required for the PP-1415/FRN-22. Use figures 244 and 245 for parts location and identification.

467. Radio Set Control C-1738/FRN-20 Repair

Repair procedures in the C-1738/FRN-20 consist of cleaning and adjustment of the relays, lever switches, dial, and minor switch K201. Use figures 246 and 247 for parts location and identification. Figure 248 contains the necessary relay adjustment data; the procedures are contained in paragraph 447 and TM 11-2103. Use TM 11-2103 for reference in all lever switch repairs and TM 11-2103 and figure 224 for repairs to dial I 201. Figure 249 contains adjustment data on minor switch K201. Instructions for repairs to K201 are contained in TM 11-2103.

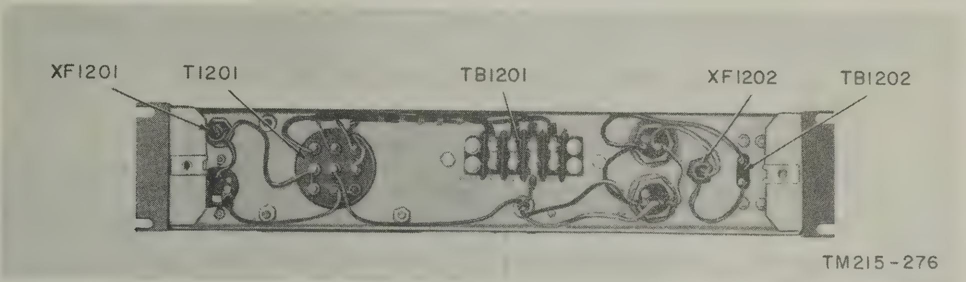


Figure 244. Power Supply PP-1415/FRN-22, interior view.

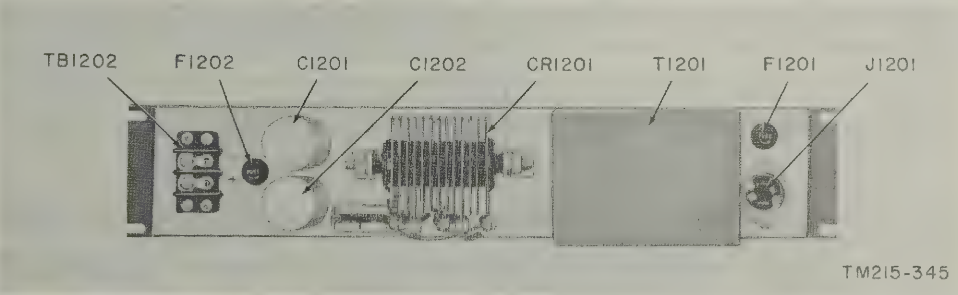


Figure 245. Power Supply PP-1415/FRN-22, rear view.

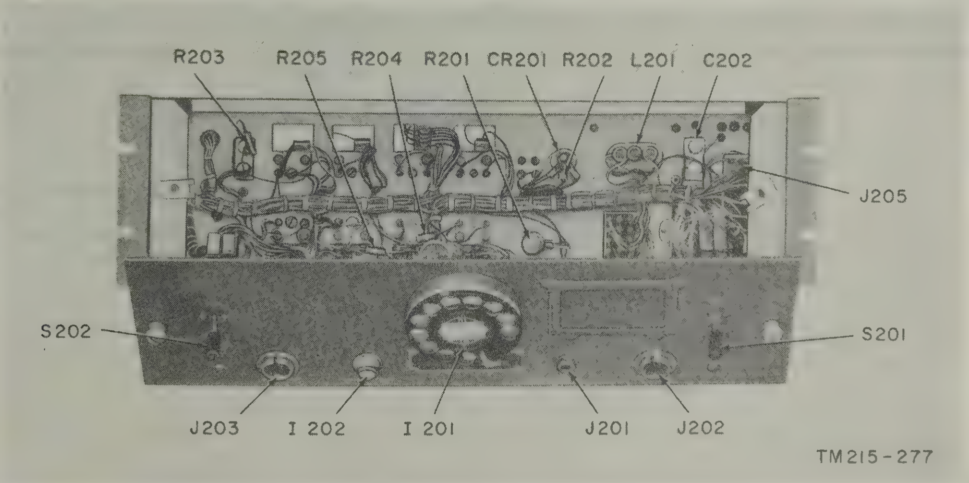


Figure 246. Radio Set Control C-1738/FRN-20, top view.

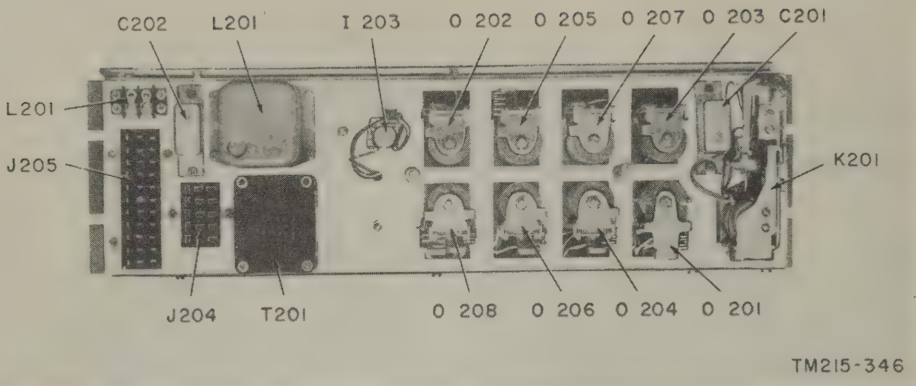
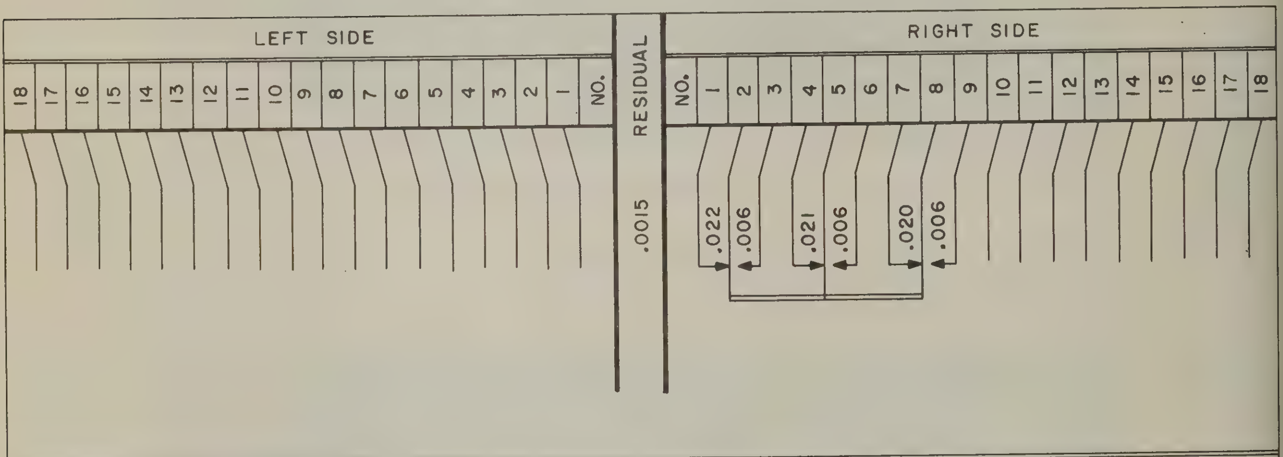


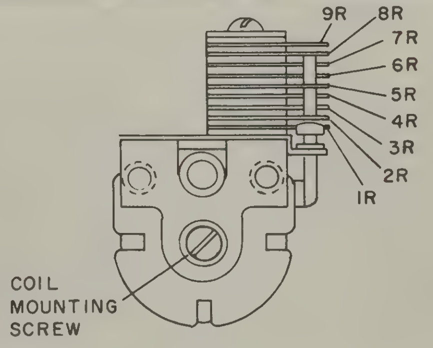
Figure 247. Radio Set Control C-1738/FRN-20, rear view.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
15 GRAMS	.045	.035	.042	.038	250 ±10%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 201	RADIO SET CONTROL C-1738/FRN-20



NOTE: ENERGIZE RELAY WITH 12V DC, CHECK DROP OUT DELAY FOR 2.0 ±.5 SECOND.

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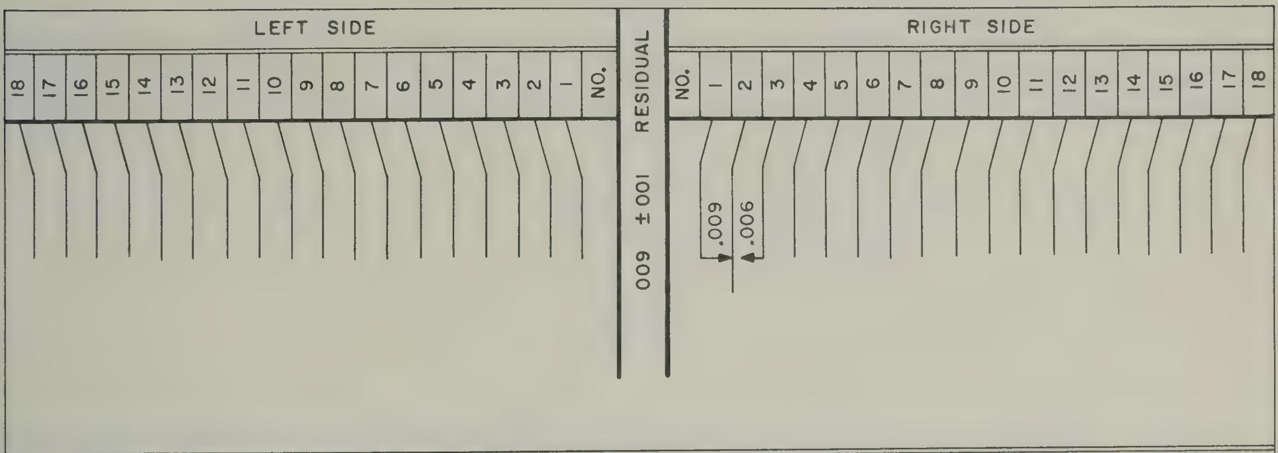
Figure 248. Relay adjustment data.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
35 GRAMS	.022	.020	.018	.015	250 ±10%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 202	RADIO SET CONTROL C-1738/FRN-20

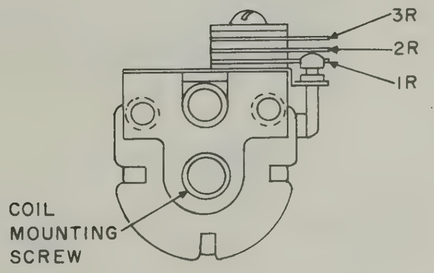


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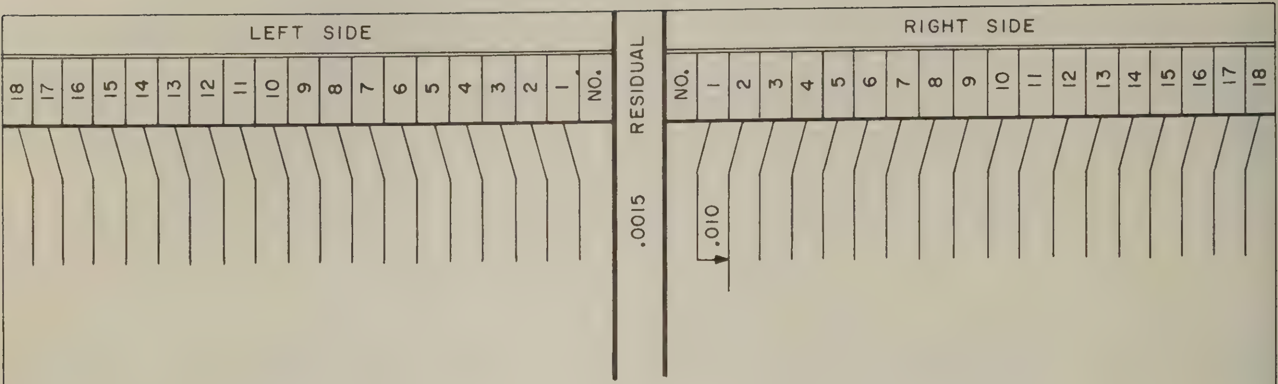
Figure 248—Continued.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
15 GRAMS	.012	.009	.011	.010	500 ±10%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 203	RADIO SET CONTROL C-1738/FRN-20

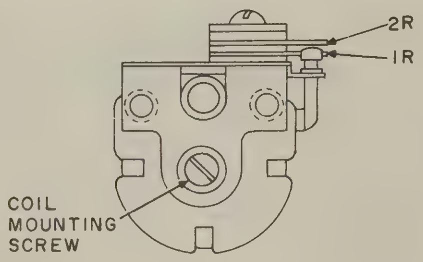


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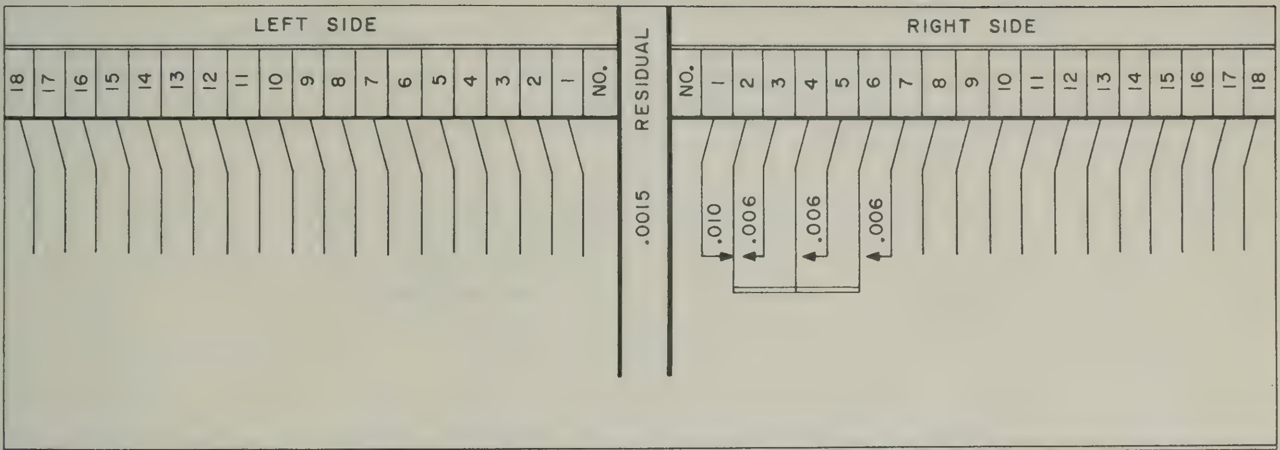
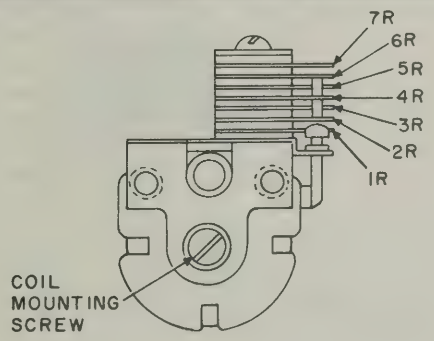
Figure 248—Continued.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
15 GRAMS	.022	.014	.019	.015	250 ±10%

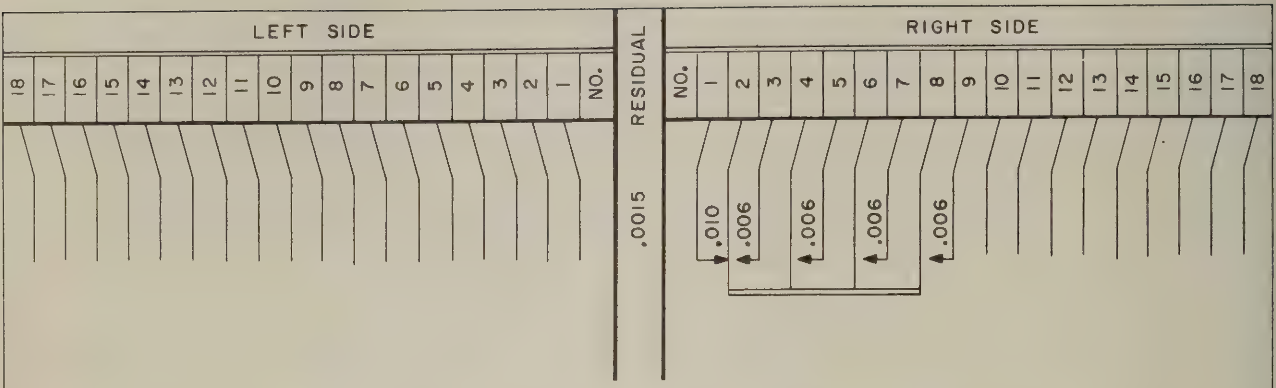
ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
0 204, 0 206	RADIO SET CONTROL C-1738/FRN-20
0 301	RELAY ASSEMBLY RE-248/FRN-22



TM215-278④

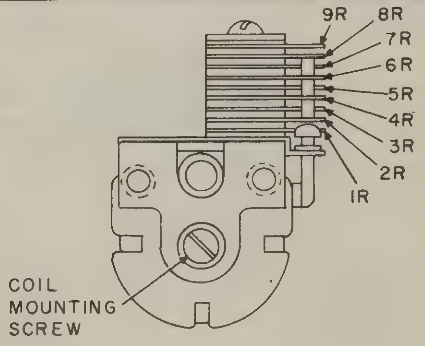
Figure 248—Continued.


LEFT SIDE
18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 NO.
RESIDUAL
.0015
RIGHT SIDE
NO. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
.010
.006
.006
.006
.006

BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
15 GRAMS	.023	.016	.021	.018	200 ± 2%

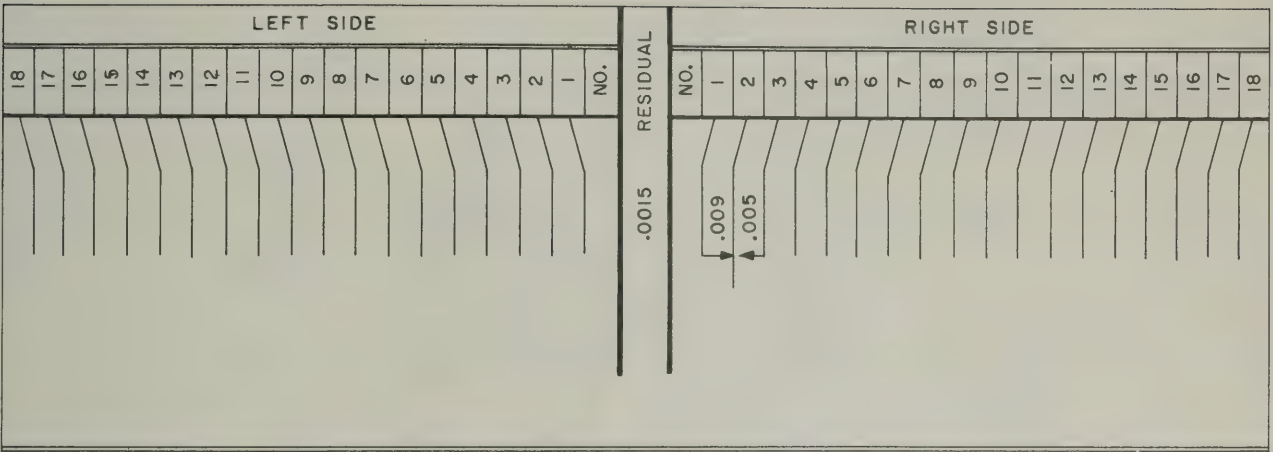
ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 205	RADIO SET CONTROL C-1738/FRN-20
O 302	RELAY ASSEMBLY RE-248/FRN-22



TM215-278 ⑤

Figure 248—Continued.


LEFT SIDE
18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 NO.
RESIDUAL
.0015
RIGHT SIDE
NO. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
.009
.005

BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
15 GRAMS	.010	.008	.010	.008	300 ± 2%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 207	RADIO SET CONTROL C-1738/FRN-20

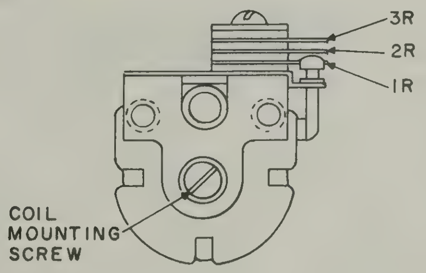


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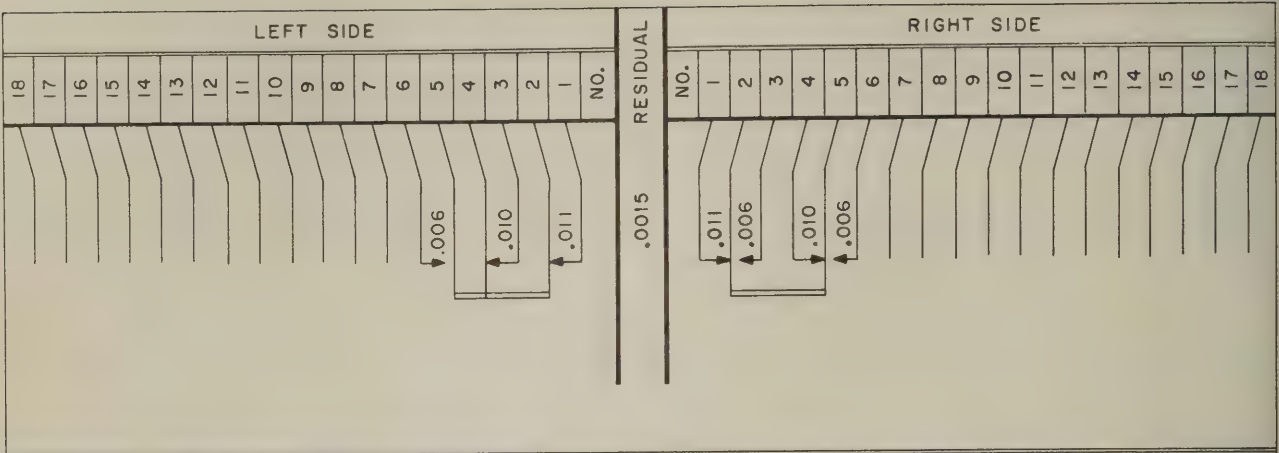
Figure 248—Continued.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
20 GRAMS	.032	.022	.028	.024	200 ± 2%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
O 208	RADIO SET CONTROL C-1738/FRN-20

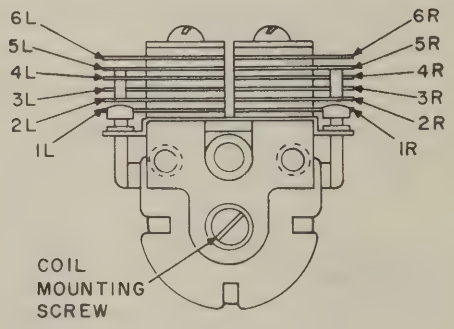


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Figure 248—Continued.

RELEASE SECTION				STEPPING SECTION			
COIL RESISTANCE (OHMS)	TEST (DC AMPERES)		STROKE (AT NORMAL)	COIL RESISTANCE (OHMS)	TEST (DC AMPERES)		STROKE (AT NORMAL)
	OPERATE	NON-OPERATE			OPERATE	NON-OPERATE	
21.4 ± 2%	.143	.116	.020	42.2 ± 2%	.248	.198	.030

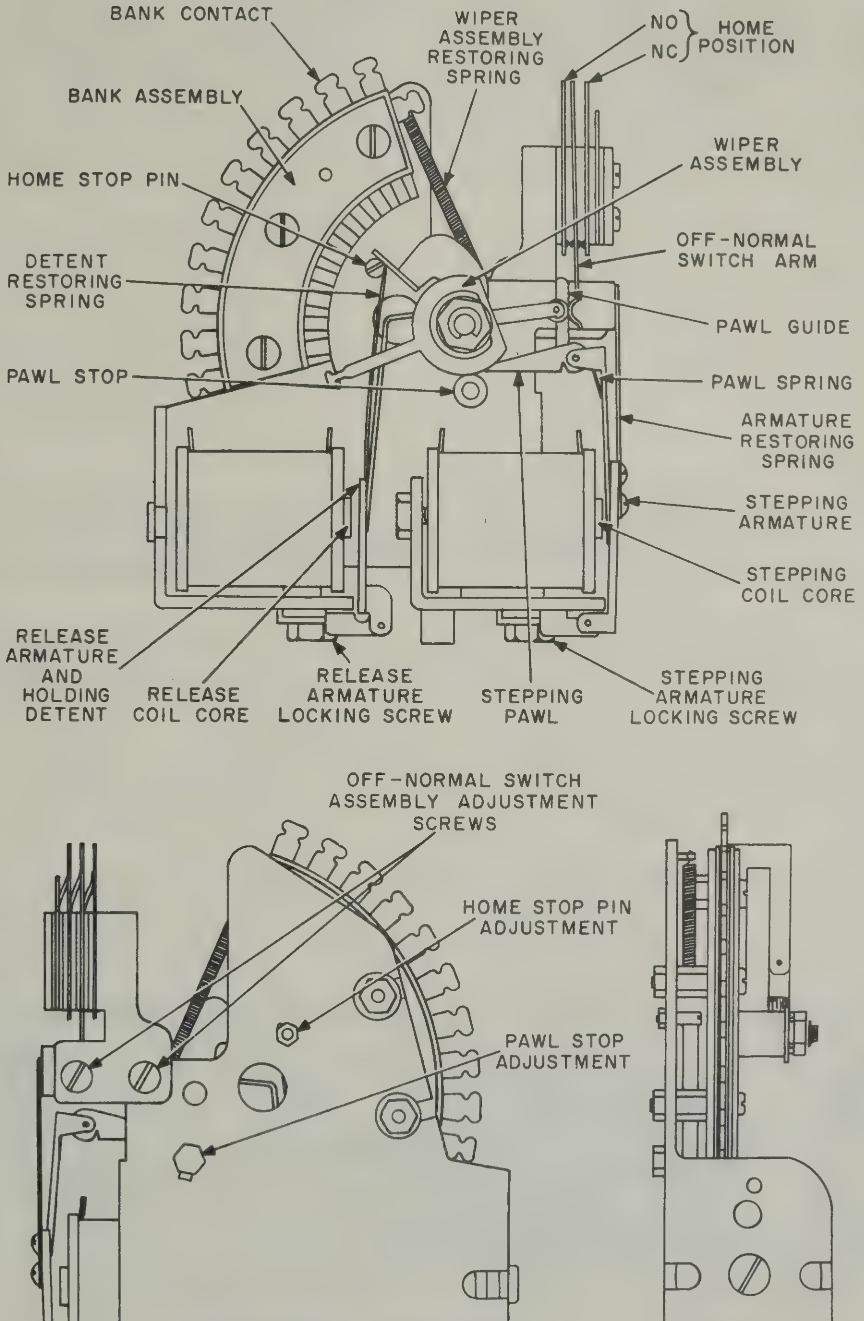

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Figure 249. Minor switch adjustment data.

468. Radio Set Transfer Control C–1840/FRN–22 Repair

a. General. Repairs to the C–1840/FRN–22 consist of parts replacement, relay, minor switch, and sequence timer adjustments. Use figures 250 and 251 for parts location and identification. Instructions for repair, replacement, and adjustment of the sequence timer (fig. 252) are given in *b* and *c* below. Refer to figures 254 and 255, paragraph 447, and TM 11–2103 for all relay repair and adjustment procedures. Use figure 256 and TM 11–2103 for minor switch K605 repairs and adjustments.

b. Sequence Timer Replacement. Replacement parts for the sequence timer are not available; therefore, the complete assembly must be replaced when an individual part is defective. Unsolder the black motor leads at the terminal strip below the chassis (station 6, fig. 313) and disconnect the leads to the switches. Remove the four sets of attaching parts that fasten the timer to the chassis and carefully lift the timer off the chassis. Check and adjust the replacement timer as instructed in *c* below and install it. Use figure 313 as a connection guide.

c. Sequence Timer Adjustment. Sequence timer adjustment procedure is described below. Use figures 252 and 253 as references throughout the procedure. Do not attempt to adjust a timer with worn cams or arms; replace the complete timer. (Adjustments are made with the timer removed from the C–1738/FRN–20.)

(1) Manually rotate the cams until all switch arms are in a notch. Check the continuity of all switches with the multimeter by operating the arms manually.

(2) Connect the timer motor leads to a source of 115 volts 60 cps. Observe the operation and note that the switches operate (click) when the arm is approximately three-quarters of the way out of the notch (fig. 253). To obtain the desired overtravel, loosen the two nuts on the end plate and shift the switches as required.

(3) With the motor operating, time the width of each notch. Use a stop watch or a sweep second hand watch. Figure 252 identifies the cams, and figure 253 indicates the time between clicks. Adjust the notch size by loosening the large nut which clamps the two cam halves together.

***Caution:* Use a wrench on the setscrew side of the cam to avoid damage to the gear train when making adjustments.**

(4) When all cam notch widths have been checked and/or adjusted, check the sequence of the cams in accordance with the time periods shown in figure 253. All timing is in relation to the START TIMING point of cam switch S601A.

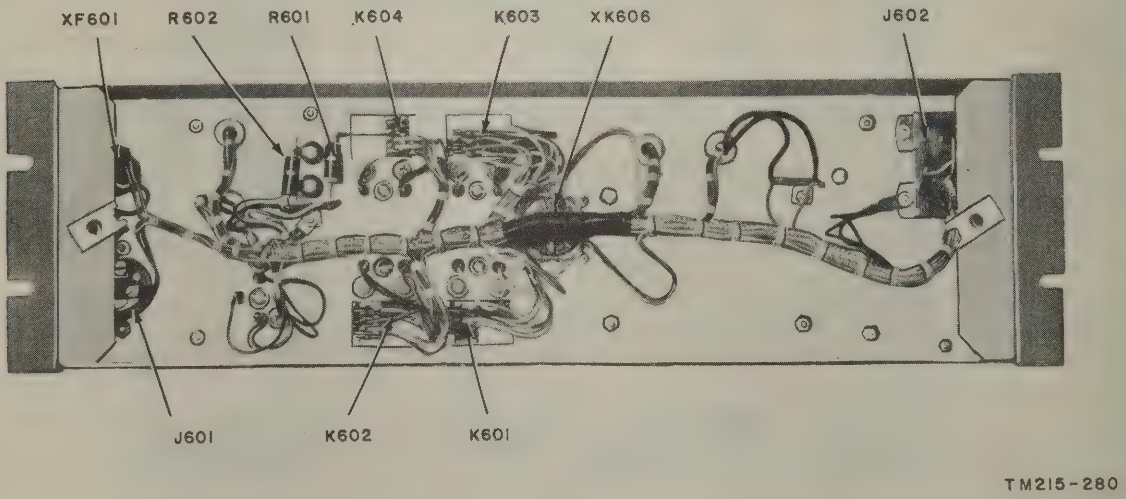


Figure 250. Radio Set Transfer Control C–1840/FRN–22, interior view.

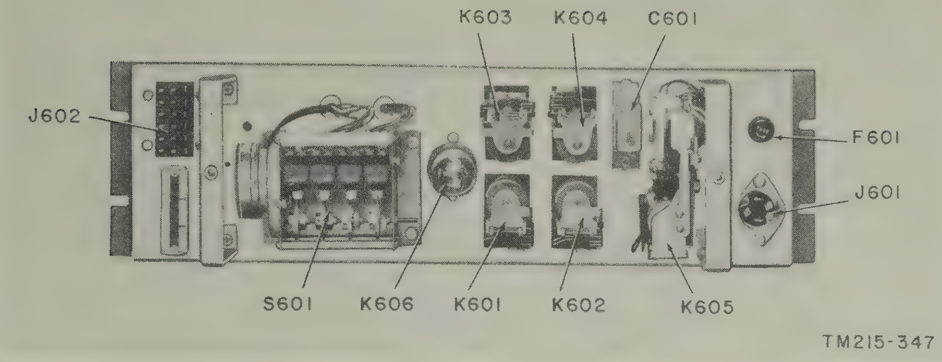


Figure 251. Radio Set Transfer Control C–1840/FRN–22, rear view.

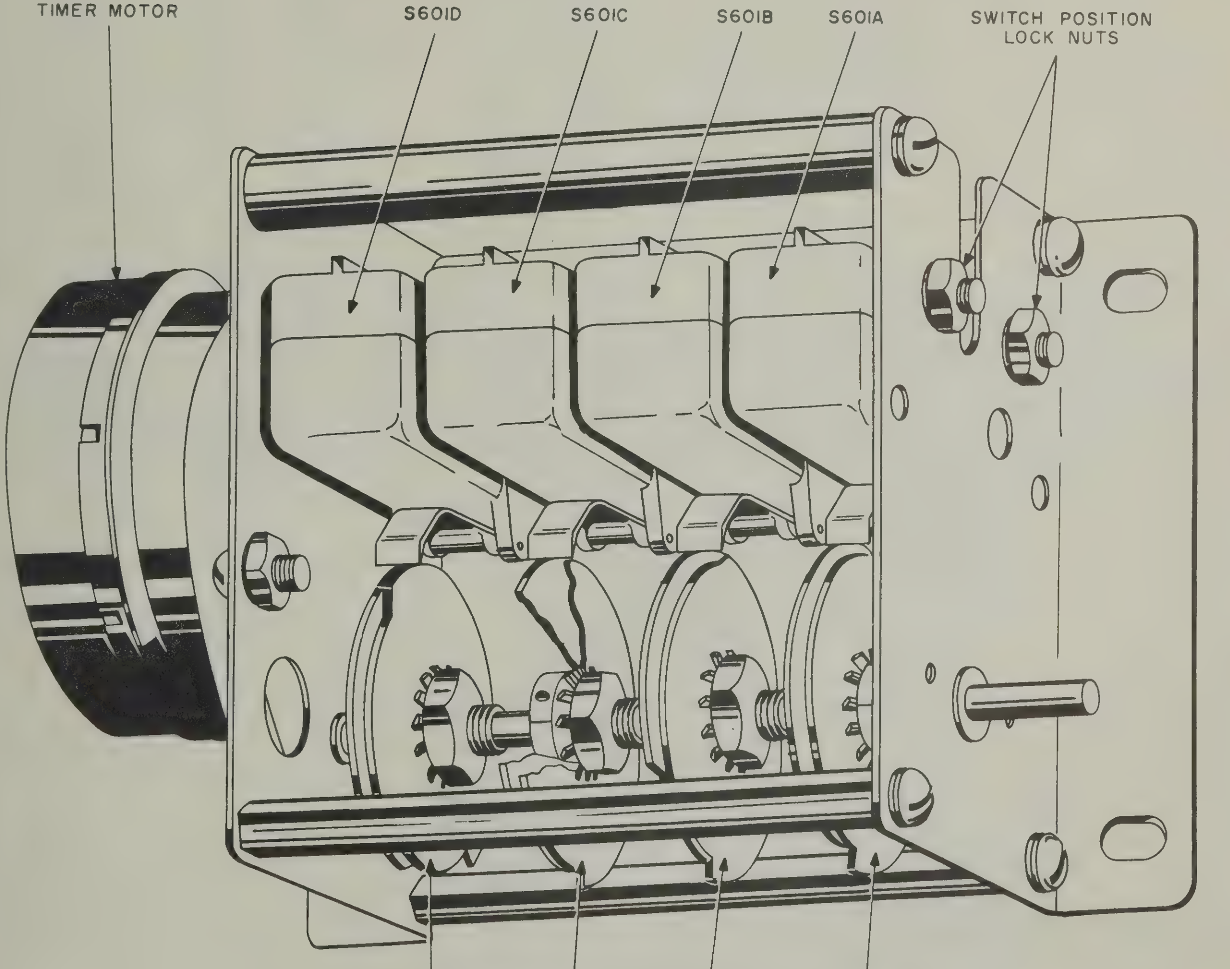
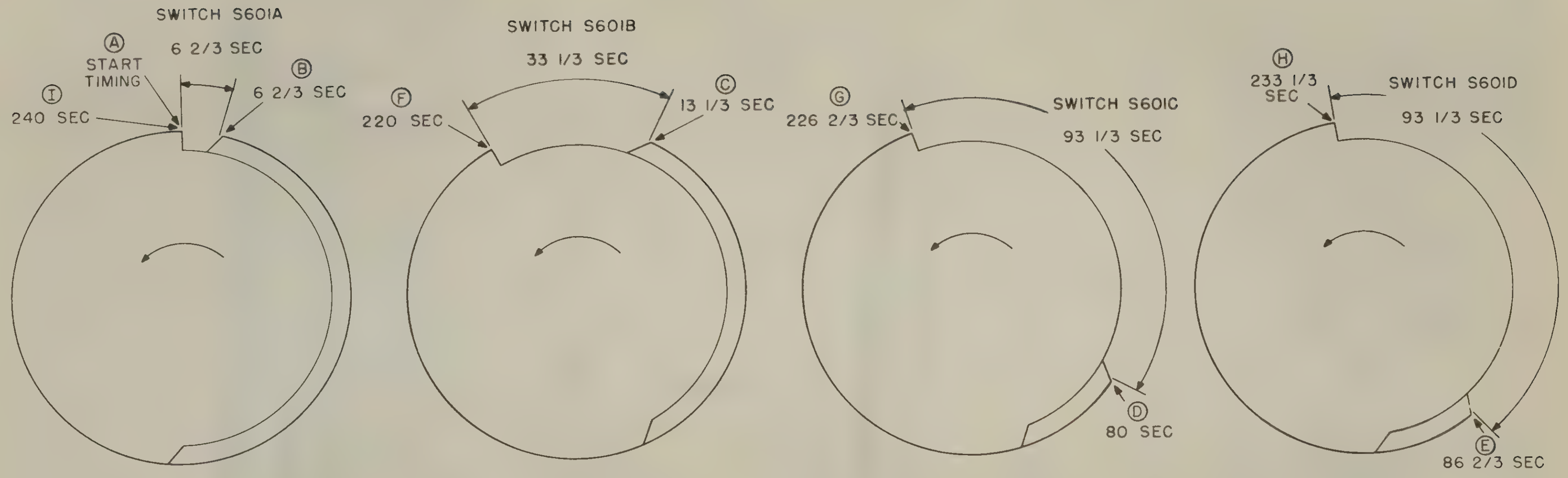


Figure 252. Radio Set Transfer Control C–1840/FRN–22, sequence timer.



NOTE:

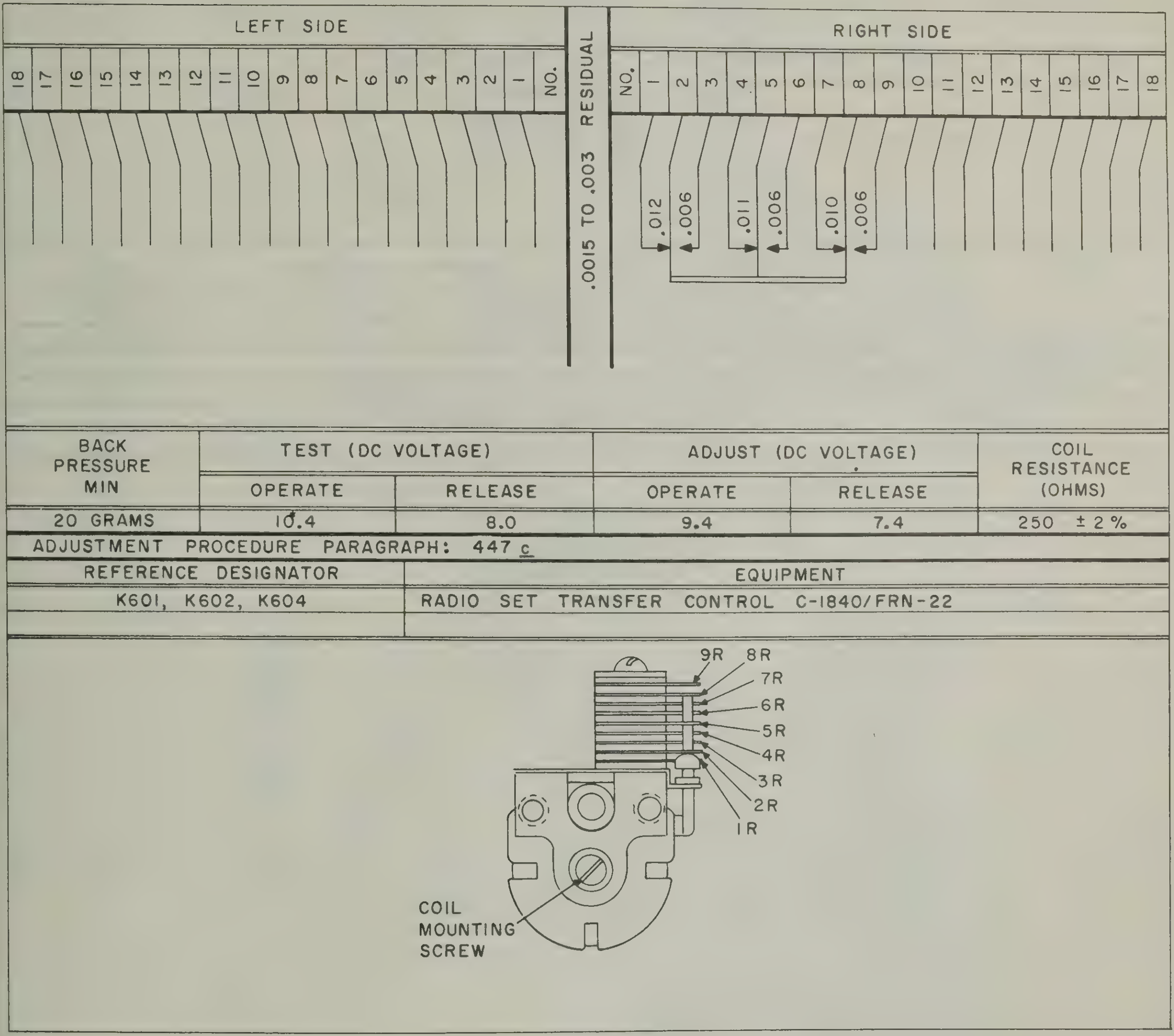
ALL TIMES BASED ON 60 CPS POWER WITH CAM ROTATING AT 1/4 RPM.
CAM ROTATES AT 1/5 RPM ON 50 CPS POWER.

Figure 253. Radio Set Transfer Control C–1840/FRN–22, sequence timer adjustment.

The starting point is best found by allowing the timer to run and noting the exact time when S601A arm drops into the notch. The switch arms should operate the switches in the alphabetical order shown in figure 253.

(5) Adjustment of the sequence timing is made by loosening the two cam hub setscrews and shifting the complete cam to the desired position in relation to the cam of switch S601A. Be sure that the cams are centered under the switch arms and that setscrews are secure after adjustment.

(6) Reinstall the sequence timer and make connections as shown in figure 252. Final test for the C–1840/FRN–22 is given in chapter 6.



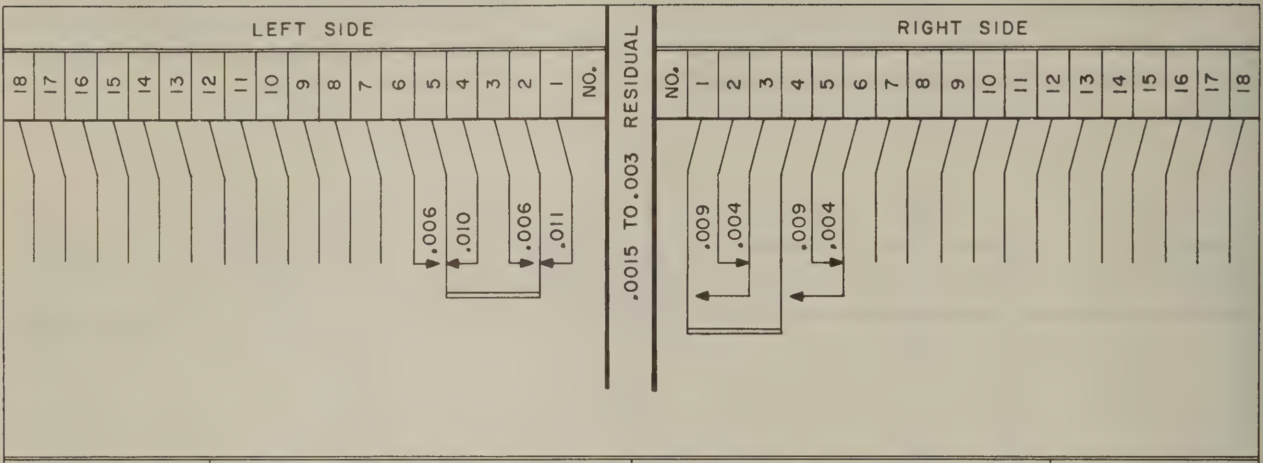
BACK PRESSURE MIN	TEST (DC VOLTAGE)		ADJUST (DC VOLTAGE)		COIL RESISTANCE (OHMS)
	OPERATE	RELEASE	OPERATE	RELEASE	
20 GRAMS	10.4	8.0	9.4	7.4	250 ± 2 %

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
K601, K602, K604	RADIO SET TRANSFER CONTROL C-1840/FRN-22

TM 215-283

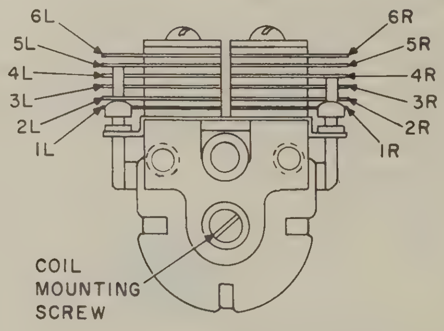
Figure 254. Relay adjustment data.



BACK PRESSURE MIN	TEST (DC VOLTAGE)		ADJUST (DC VOLTAGE)		COIL RESISTANCE (OHMS)
	OPERATE	RELEASE	OPERATE	RELEASE	
20 GRAMS	10.4	8.0	9.4	7.4	200 ± 2%

ADJUSTMENT PROCEDURE PARAGRAPH: 500 c

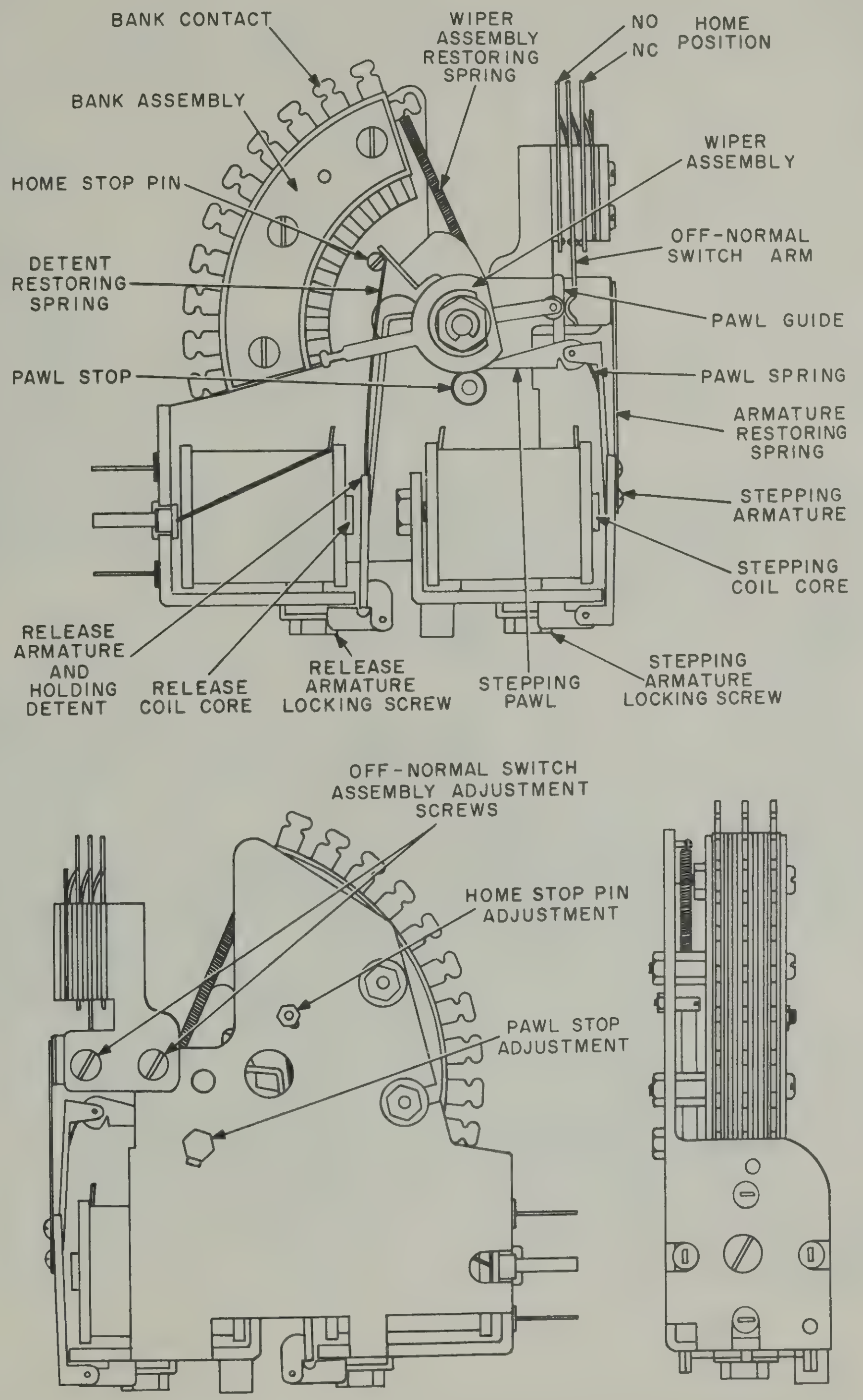
REFERENCE DESIGNATOR	EQUIPMENT
K603	RADIO SET TRANSFER CONTROL C-1840/FRN-22



TM215-348

Figure 255. Relay adjustment data.

RELEASE SECTION				STEPPING SECTION			
COIL RESISTANCE (OHMS)	TEST (DC AMPERES)		STROKE (AT NORMAL)	COIL RESISTANCE (OHMS)	TEST (DC AMPERES)		STROKE (AT NORMAL)
	OPERATE	NON-OPERATE			OPERATE	NON-OPERATE	
21.4 ± 2%	.143	.116	.020	12.2 ± 2%	.248	.198	.030



TM215-284

Figure 256. Minor switch adjustment data.

469. Radio Transmitter T–573/FRN–20 Repair

No unusual repair procedures are required in the transmitter. Figures 257 through 260 illustrate parts locations and figure 261 shows the correct positions of the neutralizing capacitors. Alinement instructions are contained in section II of this chapter. Be extremely careful when repairing the transmitter; avoid damage to RF inductors.

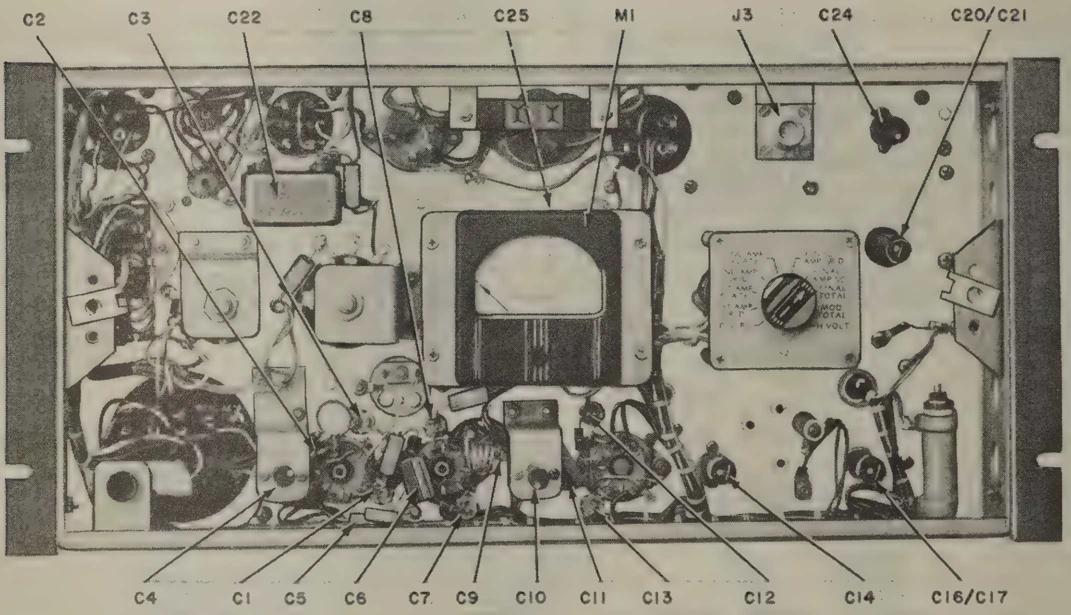


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Figure 257. Radio Transmitter T–573/FRN–20, showing resistors.

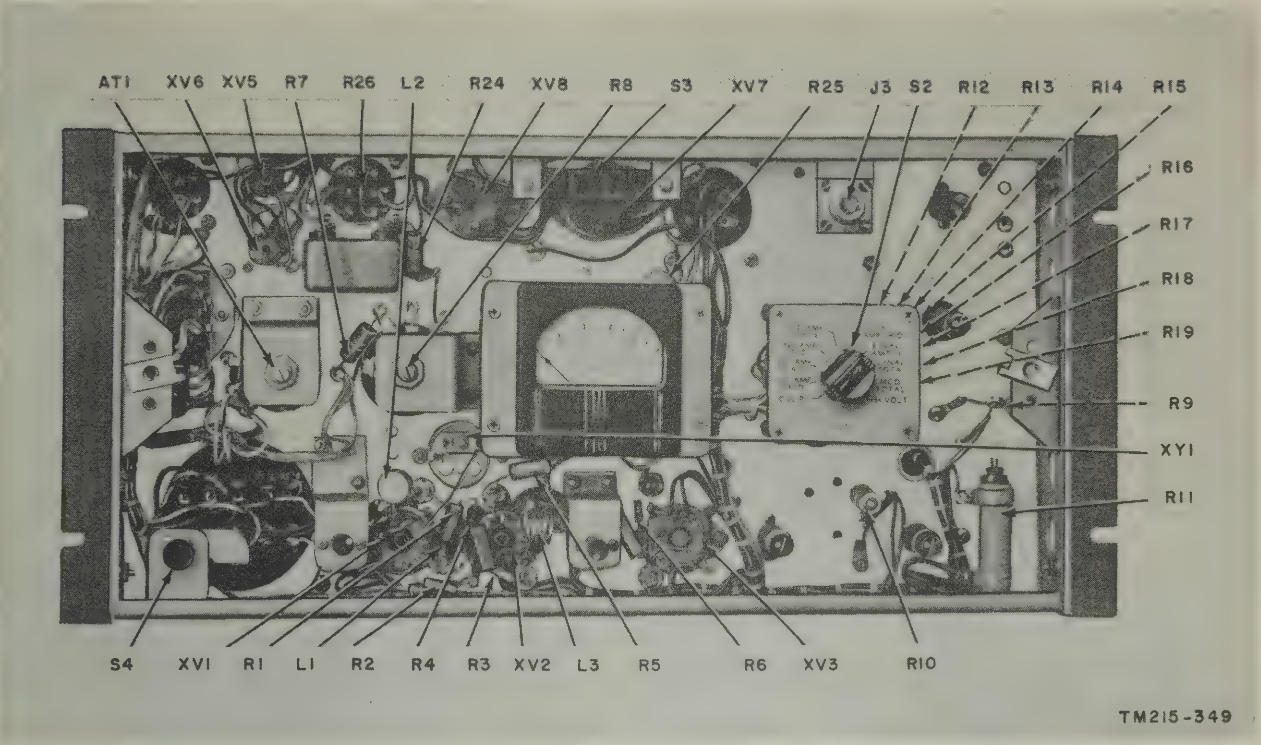

Figure 258. Radio Transmitter T–573/FRN–20, showing capacitors.

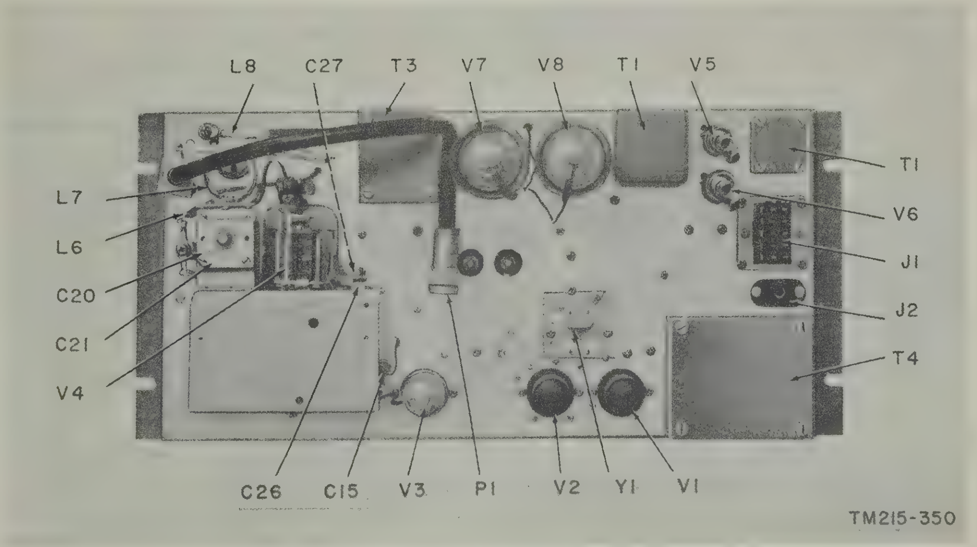

Figure 259. Radio Transmitter T–573/FRN–20, rear view.

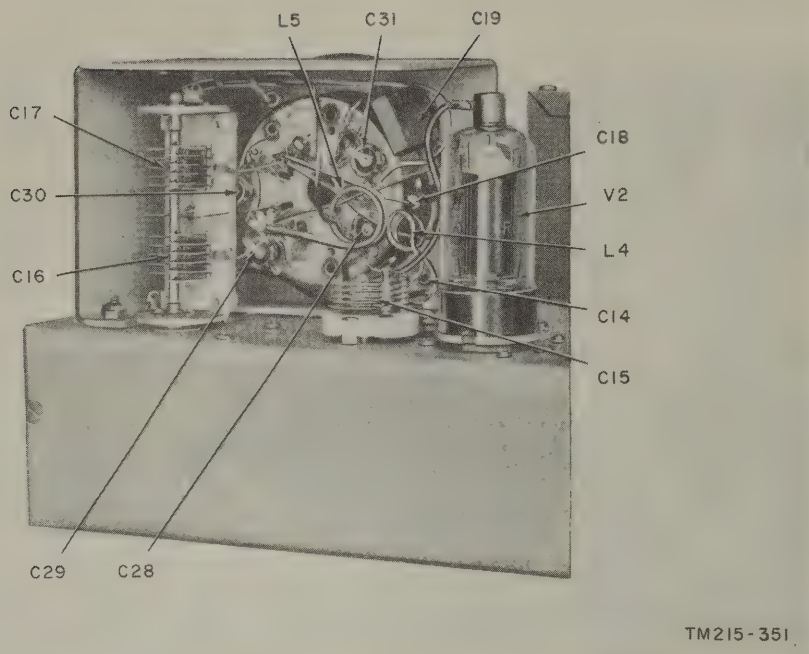

Figure 260. Radio Transmitter T–573/FRN–20, bottom view.

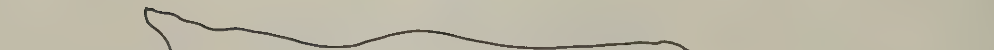

Figure 261. Radio Transmitter T–573/FRN–20, neutralizing capacitors.

470. Relay Assembly RE–247/FRN–22 Repair

Repairs to the RE–247/FRN–22 consist of standard procedures of good workmanship and the cleaning and adjustment of relays O 401, O 402, O 403, and O 404. Figures 262 and 263 illustrate the parts locations and figure 264 contains the relay adjustment data. Clean and adjust the relays in accordance with instructions given in paragraph 447.

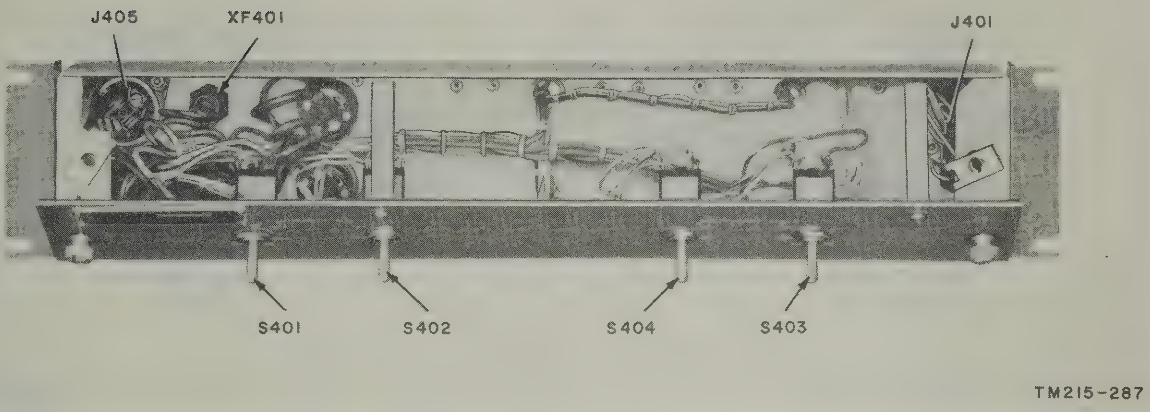

Figure 262. Relay Assembly RE–247/FRN–22, top view.

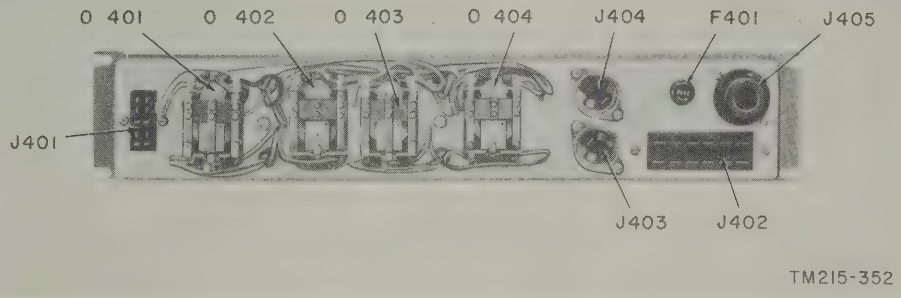

Figure 263. Relay Assembly RE–247/FRN–22, rear view.

CONTACT LOCATION	CONTACT GAP MIN	CONTACT OVERTRAVEL MIN	DEENERGIZED PRESSURE MIN	ENERGIZED PRESSURE MIN	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
CENTER	.030 INCH	.010 INCH	7 GRAMS	10 GRAMS	95 ± 2 %	6.9 ±1V DC
OUTER	.030 INCH	.010 INCH	35 GRAMS	50 GRAMS		

ADJUSTMENT PROCEDURE PARAGRAPH: 447 b

REFERENCE DESIGNATOR	EQUIPMENT
O 401, O 403	RELAY ASSEMBLY RE-247/FRN-22

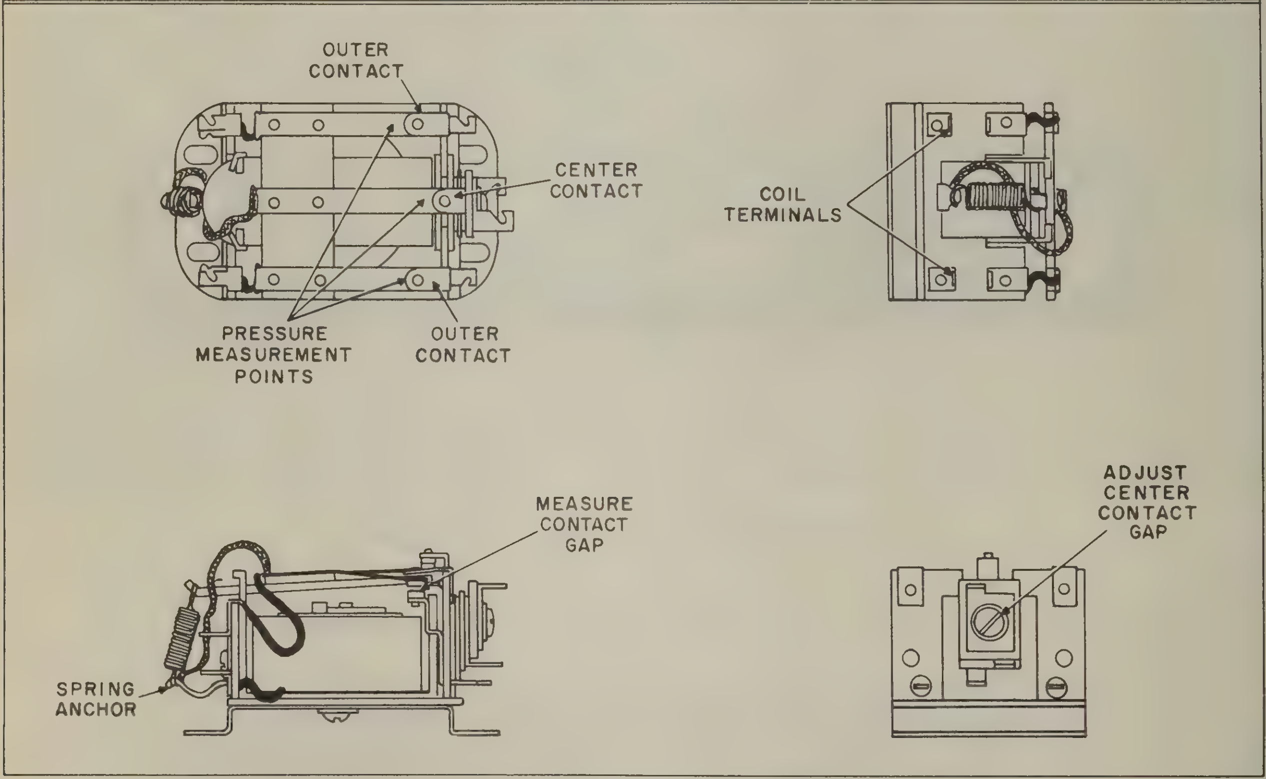

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Figure 264. Relay adjustment data.

	CONTACT GAP MIN	CONTACT OVERTRAVEL MIN	DEENERGIZED PRESSURE MIN	ENERGIZED PRESSURE MIN	COIL RESISTANCE (OHMS)	PULL IN VOLTAGE
	.035 INCH	.015 INCH	20 GRAMS	25 GRAMS	95 ± 2%	6.9 ±1V DC

ADJUSTMENT PROCEDURE PARAGRAPH: 447 b

REFERENCE DESIGNATOR	EQUIPMENT
O 402, O 404	RELAY ASSEMBLY RE-247/FRN-22

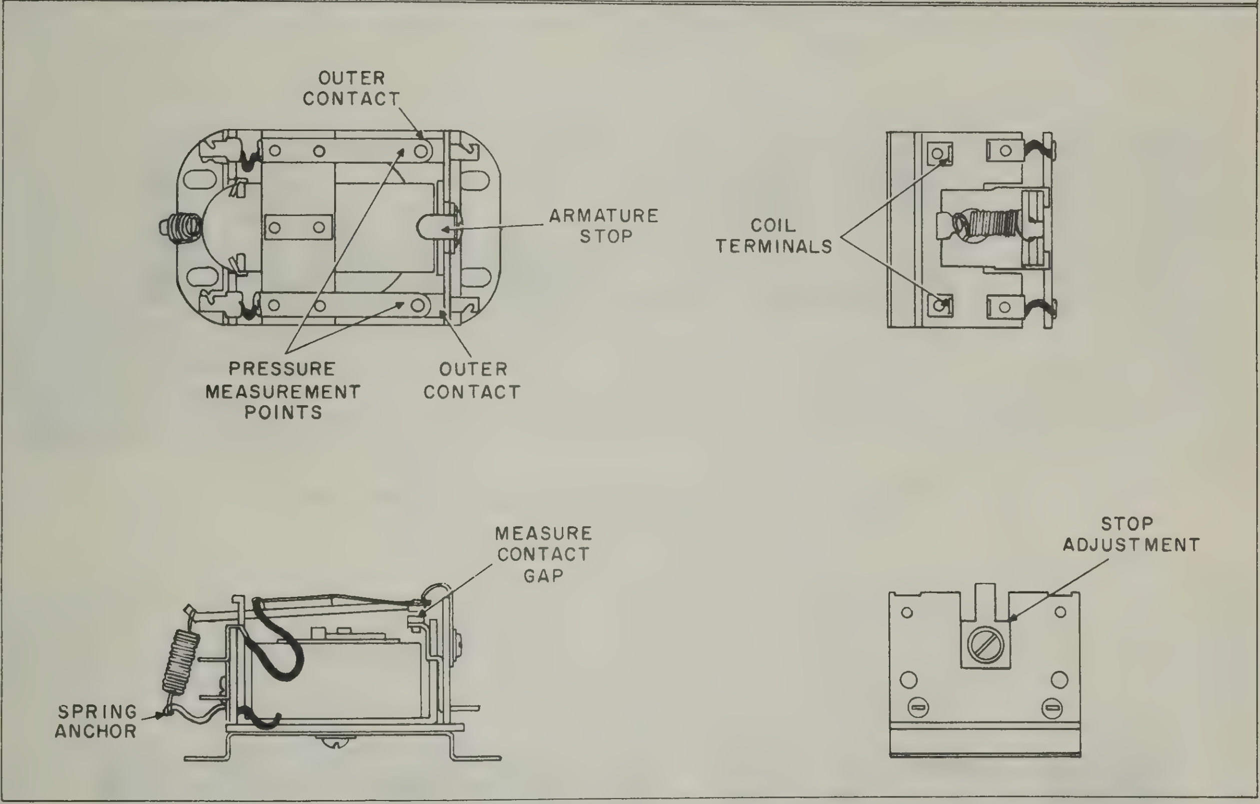

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Figure 264—Continued.

471. Relay Assembly RE–248/FRN–22 Repair

Repairs to the RE–248/FRN–22 consist of standard procedures of good workmanship and the cleaning and adjustment of relays O 301, O 302, and O 303 (fig. 265). Clean and adjust the relays in accordance with the instructions contained in paragraph 447. Adjustment data for relay O 301 are shown in figure 248, relay O 302 in figure 248 and relay O 303 in figure 267.

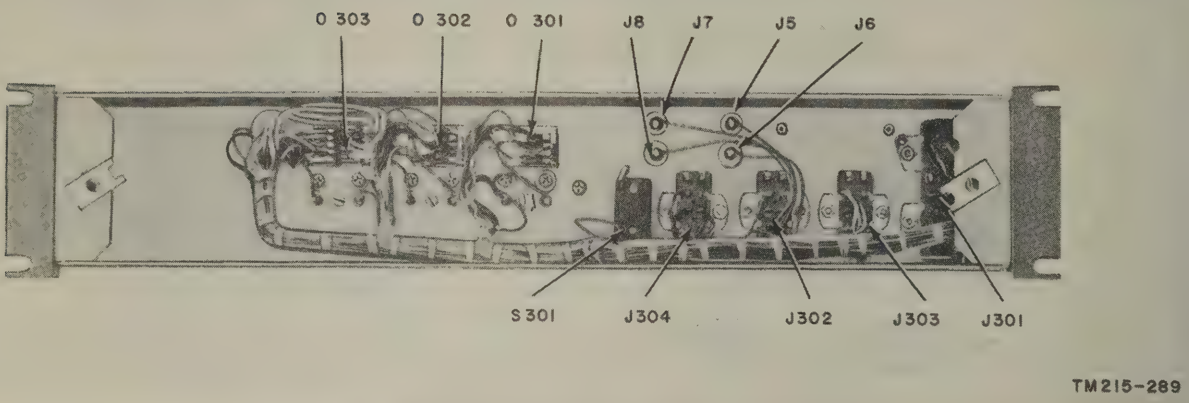


Figure 265. Relay Assembly RE–248/FRN–22, interior view.

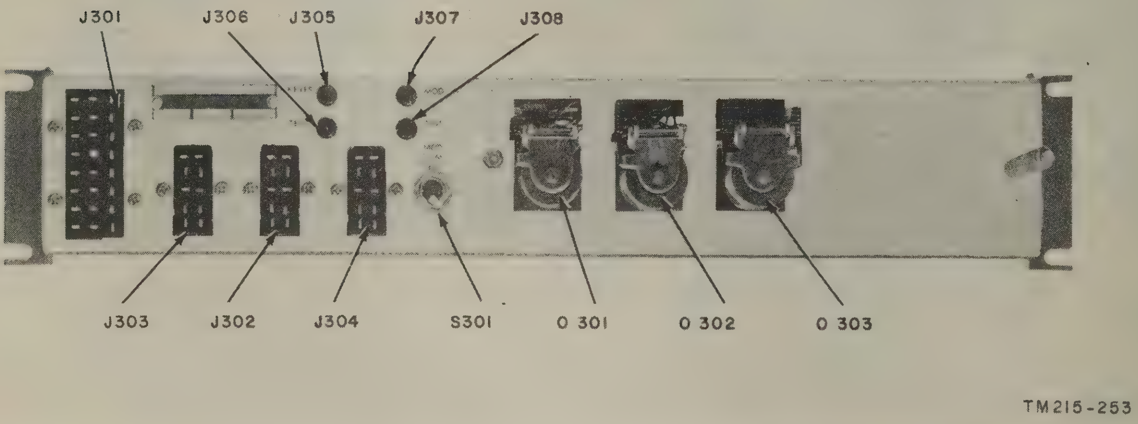
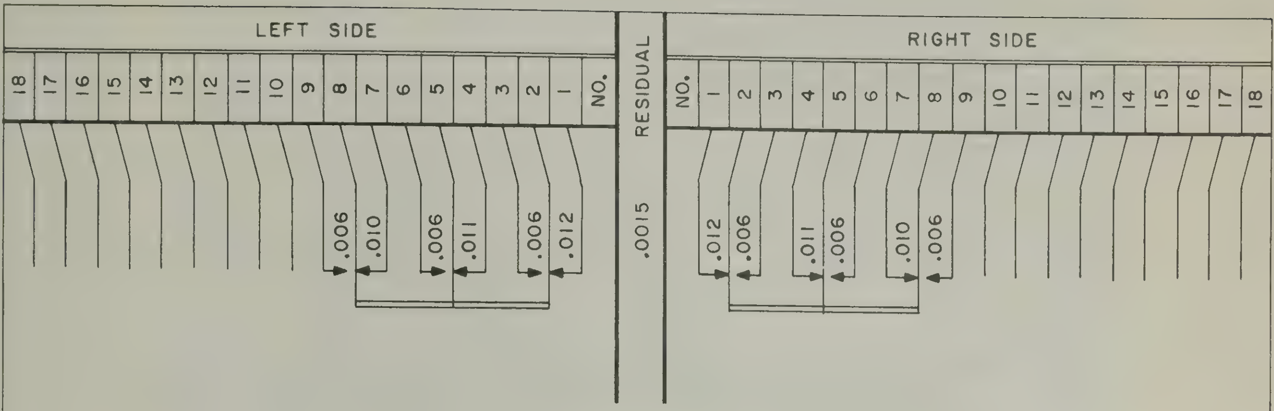


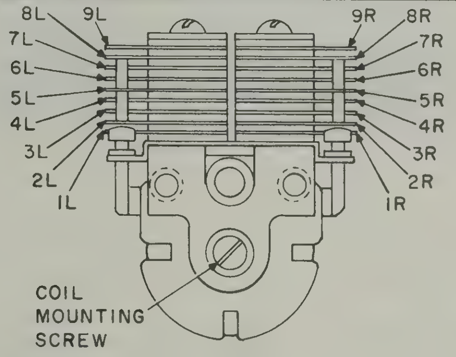
Figure 266. Relay Assembly RE–248/FRN–22, rear view.



BACK PRESSURE MIN	TEST (DC AMPERES)		ADJUST (DC AMPERES)		COIL RESISTANCE (OHMS)
	OPERATE	NON-OPERATE	OPERATE	NON-OPERATE	
25 GRAMS	.037	.027	.034	.030	200 ± 2%

ADJUSTMENT PROCEDURE PARAGRAPH: 447 c

REFERENCE DESIGNATOR	EQUIPMENT
0 303	RELAY ASSEMBLY RE-248/FRN-22



TM215-290

Figure 267. Relay adjustment data.

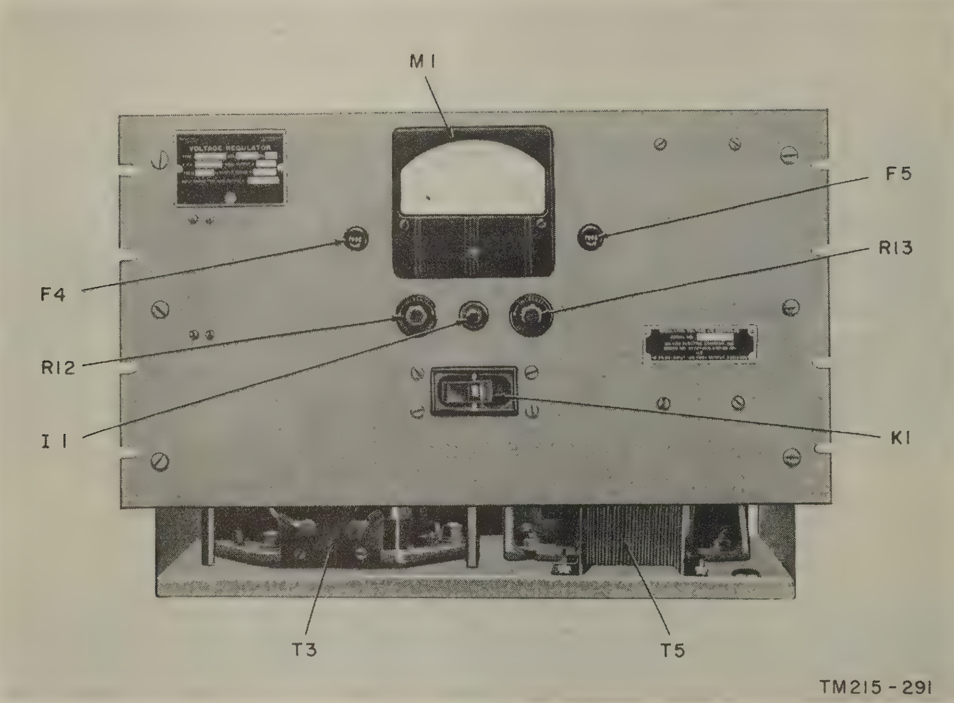


Figure 268. Voltage Regulator CN-358/FRN-22, front view.

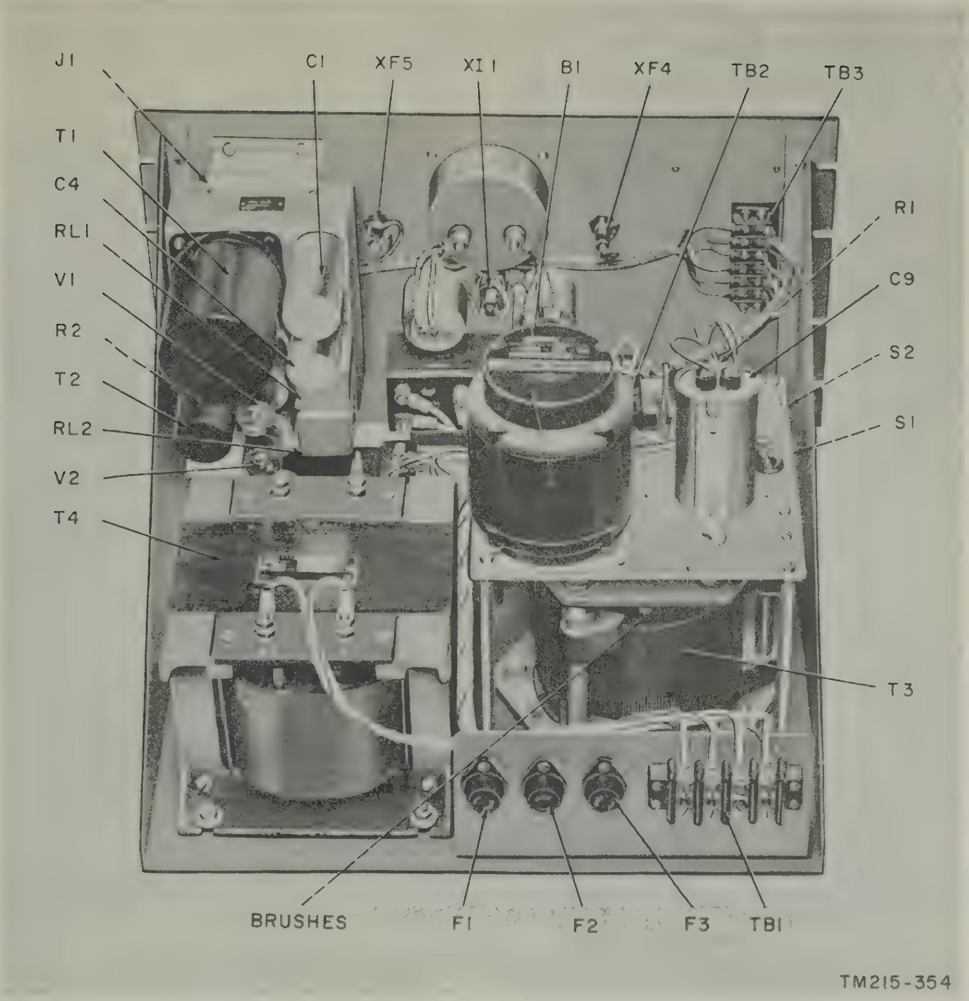


Figure 269. Voltage Regulator CN–358/FRN–22, rear view.

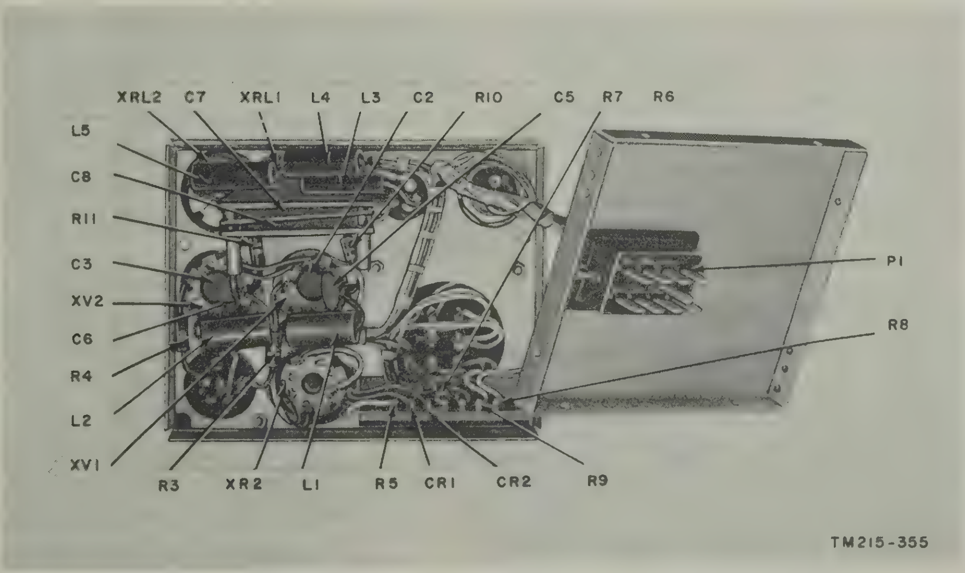


Figure 270. Voltage Regulator CN–358/FRN–22, subchassis interior view.

472. Aircraft Obstruction Marker Light MX–1919/FRN–22 Repair

No unusual repair procedures are required for the obstruction light. To prevent moisture leakage, replace gaskets whenever lamps are replaced. Figure 271 illustrates the obstruction light parts locations.

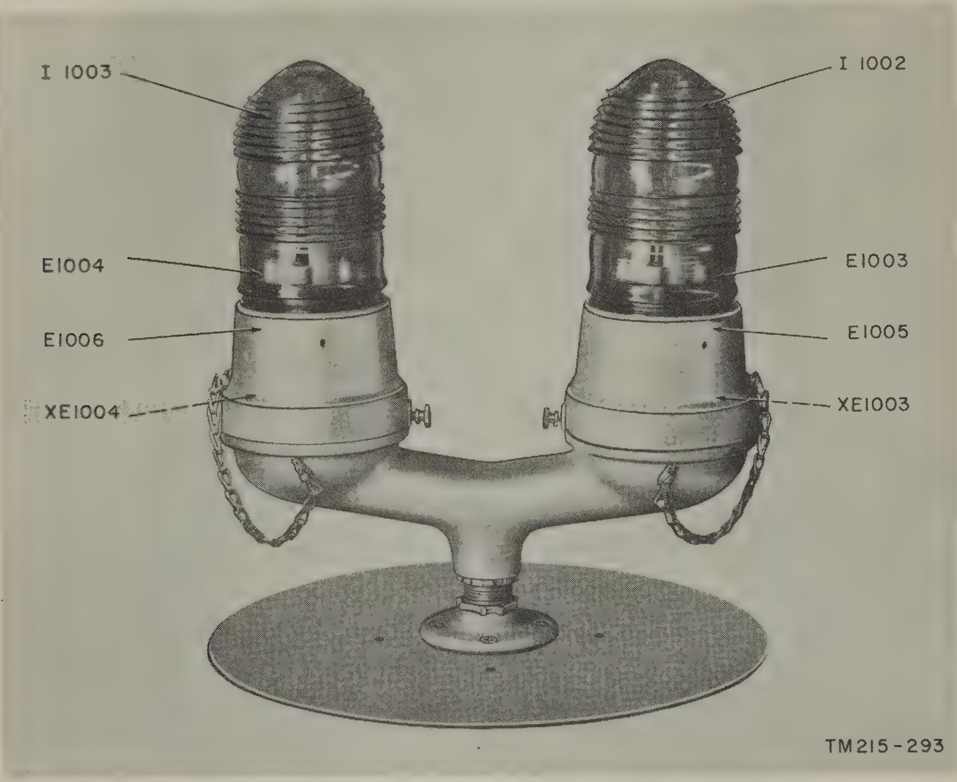


Figure 271. Aircraft Obstruction Marker Light MX–1919/FRN–22.

Section II. ALINEMENT

473. General

Alinement procedures in this section are limited because the majority of the components either do not require alinement or are alined as part of the complete omnirange set. Alternate procedures are indicated to provide alinement procedure for shops where components will be returned to stock after repair.

474. Antenna AT–669/FRN–22 Alinement

a. General. The antenna alinement consists of setting the antenna tuning adjustments as indicated in the chart accompanying the antenna and by the procedure described in paragraph 33. Adjustment of capacitors C1 and C2 is described in *b* below, where final testing indicates an unbalanced reflected power percentage (rpp) in the two variable carrier feed lines.

b. Adjustment of Capacitors C1 and C2. Do not attempt this adjustment if either variable feed line rpp is greater than 1 percent. Use the following procedures to obtain equal rpp in both feed lines below the 1 percent value. The test equipment indicated in paragraph 250 and the test setup given in paragraph 253 are used for this adjustment.

(1) Connect coaxial cable W2 (fig. 16) and the antenna to the line wattmeter and measure the rpp (par. 253). Do the same for cable W4 and the antenna.

(2) Attempt to reduce the rpp of the higher cable by capacitor adjustment (capacitor C1 (fig. 43) for cable W2 and C2 for W4). Make a very slight adjustment of the appropriate capacitor and check to determine whether the rpp was lowered.

If it increased, set the capacitor opposite the original setting. Be sure that the radomes are installed for all tests.

(3) If the rpp cannot be lowered by the method indicated in (2) above, adjust the capacitor concerned with the lower rpp in small increments to make the rpp values equal. *Do not allow either rpp value to exceed 1 percent.*

475. Antenna Group AN/FRA–14 Alinement

Alinement procedure for the AN/FRA–14 is given in paragraph 43. Because of the simplicity of the AN/FRA–14 and its operating characteristics, no other method is considered practicable.

476. Course Monitor MX–1837/FRN–20 Alinement

The alinement and adjustment procedure contained in paragraph 50 is used for the monitor after repair when the monitor is to be returned to the omnirange set. The bench test setup of figure 179 may be made with the procedure given in paragraph 50. *Do not attempt any adjustment of capacitor C2 in the reference carrier filter.*

477. Electrical Goniometer GO–12/FRN–20 Alinement

a. General. Alinement of the goniometer consists of adjustments to the subcarrier subchassis only. Refer to paragraph 326 for test equipment requirements and to paragraph 329 for the equipment connections. Figure 230 illustrates the adjustment locations referred to in the subparagraphs below.

b. Fixed Oscillator Alinement. Complete a frequency check as instructed in paragraph 333 and adjust inductor L1 (fig. 243) to 190.04 kc ±1 kc as indicated by the frequency meter. Gently tap the subchassis to insure that no change in frequency takes place with vibration.

c. Swept Oscillator Adjustment. Complete a frequency check as instructed in paragraph 333 with the azimuth plate set at 90°. Adjust inductor L2, (fig. 230) to obtain a frequency of 200 kc ±1 kc as indicated by the frequency meter. Check the frequency at 270° and adjust L2 to obtain a frequency within the plus or minus range of 1 kc at 90° and 270°. Gently tap the subchassis to check for stable frequency during vibration.

478. Modulation Eliminator MX–1843/FRN–20 Alinement

The modulation eliminator alinement is best performed while it is installed as part of the omnirange set. It may be accomplished by using the bench test setup indicated in paragraph 351. The adjustment of capacitor C7 is fully described in paragraph 46.

479. Radio Transmitter T–573/FRN–20 Alinement

Alinement of the transmitter is completely described in paragraph 39. The bench test setup instructions in paragraph 413 may be followed, together with the procedure described in paragraph 39.

CHAPTER 6

FINAL TESTING

Section I. GENERAL

480. Purpose of Final Testing

The tests outlined in this chapter are designed to measure the performance capability of a repaired component. Components that meet the minimum standards stated in the tests will furnish satisfactory operation, equivalent to that of new equipment. Final testing of the complete omnirange set is accomplished by completion of the test chart procedures shown in paragraph 229.

481. Test Equipment Required for Final Testing

The test equipment required for final testing is the same as that listed for troubleshooting (par. 230). The equipment to be used for final testing a specific component is described in the section assigned to that component.

482. Test Setups for Final Testing

Each final testing section contains a specific reference to the proper test setup to be used. Any test setup or operational condition which differs from that of the referenced material will be fully explained in the section for the specific component.

Section II. ANTENNA AT–669/FRN–22 FINAL TESTING

483. General

Final testing of the antenna is based on the overall operation of the omnirange set as determined by a flight check and reflected power percentage measurements. All testing must be accomplished at the omnirange site with the transmitting equipment that will be used to excite the antenna. The antenna tuning adjustments must be set in accordance with the procedure given in paragraph 33 and the chart shipped with the antenna. *Do not* use the values shown on the typical tuning chart shown in figure 40.

a. Test Equipment. The test equipment required for final testing is the same as that listed for troubleshooting (par. 250). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedure described in paragraph 253 are used to complete the antenna final testing procedure. Be sure that both transmitting equipments are calibrated in accordance with instructions contained in paragraph 253*a*.

484. Reflected Power Percentage Test

Check the rpp of the antenna as directed below. Rpp is to be calculated in accordance with instructions contained in paragraph 253*b* and with the general test setup shown in figure 169.

a. Disconnect each antenna feed line (W2, W4, and W5 in fig. 16) at the antenna and connect it individually to the line wattmeter (A, fig. 169).

b. Measure the rpp of the three coaxial feed lines. The rpp of the feed lines should be less than 1 percent and cables W2 and W4 balanced to within ½ of 1 percent.

c. Measure the rpp with cables W2, W4, and W5 as they are normally connected to the antenna relays. Use the setup shown in figure 169, with the line wattmeter connected to the input receptacles (N/J1003 through N/J1011) individually. Use the appropriate transmitter (equipment No. 1 or No. 2) which normally feeds these receptacles. Rpp and balance must be the same as shown in *b* above.

485. Fight Check

Flight checks must be conducted by pilots who are experts in aircraft that is equipped with special receiving units having crystal-controlled frequency selectors that are calibrated as accurately as possible. Receiving equipment used should comply with current regulations set forth by the commanding officer. Three general categories of information are desired with respect to the omnirange set. They are course accuracy, course quality (or flyability), and coverage.

a. Course Accuracy. Bearing accuracy is most expeditiously checked by an orbital flight around the omnirange site. The plane must fly in a counterclockwise direction about the station at a fixed radius and record the azimuth indication at 10° intervals. Wind velocity must be below 10 knots and accurately located ground checkpoints used. The distance from the station to the aircraft must be at least 20 miles and the aircraft flown at a constant altitude and bank angle. The course accuracy must be within the tolerance of current regulations and specifications of the commanding officer.

b. Course Quality (Flyability). These checks include course width, course sensitivity, radial flyability (course roughness, scalloping, and bends), and attitude. In these checks, the degree of error may not be as important as the rate of change. Courses must comply with current regulations and specifications of the commanding officer.

c. Coverage. Coverage flight checks must be made at the minimum altitude specified in current regulations and specifications of the commanding officer. These checks will reflect the distance at which minimum altitudes will produce accurate navigational information.

d. Records. Record all information obtained by flight checks for future use as required by current regulations and specifications of the commanding officer.

Section III. ANTENNA GROUP AN/FRA–14 FINAL TESTING

486. General

The signal output test must be accomplished with the AN/FRA–14 tuned and mounted in its normal operating position at the omnirange site. Two tests are required to check the performance: the V1 contact potential and the signal output.

a. Test Equipment. The test equipment required for final testing is the same as listed for troubleshooting (par. 257). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 259 are used to complete the AN/FRA–14 final testing. Be sure that both transmitting equipments are functioning properly.

487. Contact Potential Test

a. Connect the AN/FRA–14 for normal operation (fig. 16) but disconnect plug P9 from the monitor and connect the multimeter to plug P9. Set the multimeter FUNCTION switch to DIRECT position, 2.5-volt range, and connect the positive test lead to the center pin of plug P9. Connect the negative test lead to the shell of P9.

b. Place the interlock jumper plugs in interlocks S801 and S802 of the CY–1897/FRN–22 cabinet. Do not energize either transmitting equipment until instructed to do so (par. 488). (Circuit breaker N/K1003 must be closed and the monitor OFF at all times.)

c. Measure the contact potential with the multimeter. The maximum voltage permissible is 0.1 volt dc.

488. Signal Output Test

a. Complete the procedures given in paragraph 487. Use the vtvm ac probe and connect it as indicated in paragraph 487*a*.

b. Energize equipment No. 1 and then No. 2 and record the vtvm reading for each transmitting equipment. Both equipments must produce a signal output of 0.3 volt ac or more.

Section IV. AUDIO FREQUENCY AMPLIFIER AM–1246/FRN–20 FINAL TESTING

489. General

Final testing of the AM–1246/FRN–20 consists of continuity checks, overall gain measurement, distortion and noise measurements.

a. Test Equipments. The test equipment required for final testing is the same as that listed for troubleshooting (par. 265), with the addition of a spectrum analyzer. Use the technical manuals listed in paragraph 265*a* for the remaining test equipments.

b. Test Setup. The test setup and procedures described in paragraph 267 are used to complete the AM–1246/FRN–20 final testing. Be sure that the PP–1329/FRN–20 is functioning properly.

490. Continuity Tests

Complete the checks shown in the chart below. Use the multimeter for measurements. All external connections and power must be removed during continuity checks.

Test point terminals (fig. 206)	Resistance (ohms)
J4 pin 1 and chassis	Zero.
J4 pin 4 and chassis	4,500 to 5,550.
J4 pin 8 and chassis	2.
J4 pin 7 and chassis	2.
J3 and chassis	Infinite.
J4 pins 5 and 8 (R7 fully ccw)	40 min.
J4 pins 9 and 12 (S1 closed)	Zero.

491. Gain Test

Connect the AM–1246/FRN–20 to the PP–1329/FRN–20 as instructed in paragraph 267. Maintain a constant 230-volt ac input during all tests.

a. Set the AF oscillator for a 60-cps, 1.5-volt output and connect it as shown in figure 171. Measure the signal output with the AF vtvm across terminals A and C of J1401 in the PP–1329/FRN–20 (fig. 240). The value should be at least 115 volts ac with attenuator R1 (fig. 207) set fully clockwise.

b. Rotate R1 fully counterclockwise with the same input indicated in *a* above; attenuation should be 40 db minimum.

492. Distortion and Noise Test

Connect the equipment as instructed in paragraph 491 and connect the spectrum analyzer across terminals A and C of J1401 (fig. 171). Supply a constant 230-volt ac input during all tests.

a. Set the AF oscillator to 1,000 cps and 170 millivolts output. Distortion should be less than 5 percent with attenuator R1 fully clockwise.

b. Use the same input connections as indicated in *a* above but with no signal input; the noise should be 45 db below the level obtained with the 1,000-cps signal (*a* above).

Section V. AUDIO FREQUENCY AMPLIFIER AM–1247/FRN–20 FINAL TESTING

493. General

Final testing of the AM–1247/FRN–20 consists of gain, distortion, noise, frequency response, and compression measurements.

a. Test Equipment. Test equipment required for final testing is the same as that listed for troubleshooting (par. 276) with the addition of a spectrum analyzer. Use TM 11–5097 for the spectrum analyzer operating instructions, and the appropriate technical manuals listed in paragraph 276*a* for the remaining test equipments.

b. Test Setup. The test setup and procedures described in paragraph 278 are used to complete the AM–1247/FRN–20 final testing.

494. Gain Test

Connect the AM–1247/FRN–20 as instructed in paragraph 279 and provide a constant source of 115 volts ac. Rotate gain control R1 (fig. 210) and compression control R16 to the fully clockwise position.

a. Set the AF oscillator for 1,000 cps at —60 db input to the AM–1247/FRN–20. The measured gain across the load resistor (fig. 173) should not be less than 60 db or greater than 75 db.

b. With the AF oscillator set for 1,000 cps and with sufficient output to produce a 6-db amplifier output, the ac voltage between pins 1 and 3, and 3 and 4 of receptacle J2 (fig. 210) should be within 5 percent of each other.

495. Distortion and Noise Test

Connect the AM–1247/FRN–20 as instructed in paragraph 279 and provide a constant source of 115 volts ac (gain control R1 and compression control R16 fully clockwise).

a. Connect the spectrum analyzer across the load resistor (fig. 173) and measure the distortion at the AM–1247/FRN–20 output of 0 db, 4 db, 8 db, and 10 db. Distortion should be less than 5 percent at all output levels.

b. After compression control R16 adjustment (par. 497), measure the distortion at 0 db output level. Distortion should be less than 5 percent with R16 properly adjusted.

c. Adjust the AF oscillator for 0-db (1.73 volts ac) input to the AM–1247/FRN–20 at 1,000 cps. With no signal input, the noise level should be greater than 35 db below the level obtained with 0-db input.

496. Frequency Response Test

Connect the AM–1247/FRN–20 as instructed in paragraph 279 and provide a constant source of 115 volts ac (gain control R1 in fig. 210 and compression control R16 fully clockwise).

a. Set the AF oscillator for a 0-db output at 1,000 cps, as measured with the AF vtvm across the load resistor.

b. Check the output voltage at 250, 500, 750, 2,000, 3,000, 4,000 and 5,000 cps. The output level should not vary more than ±3 db from the 1,000-cps level.

c. After compression control R16 adjustment (par. 497), recheck the frequency response as shown in *b* above. The output level should not vary more than ±2 db from the 1,000-cps level.

497. Compression Test

Connect the AM–1247/FRN–20 as instructed in paragraph 279 and provide a constant source of 115 volts ac.

a. Set the AF oscillator for 2 millivolts (1,000 cps) input to the AN–1247/FRN–20. Adjust gain control R1 to produce a 3-db output level across the load resistor.

b. Adjust compression control R16 (fig. 210) to reduce output to 0 db at 1,000 cps.

c. Increase the AF oscillator output to 25 millivolts; the AM–1247/FRN–20 output should not be greater than 6 db.

Section VI. AUDIO FREQUENCY OSCILLATOR O–371/FRN–20 FINAL TESTING

498. General

Final testing of the O–371/FRN–20 consists of frequency range and stability, output, distortion, time delay, and continuity measurements.

a. Test Equipment. Test equipment required for final testing is the same as that listed for troubleshooting (par. 286) with the addition of a spectrum analyzer. Use TM 11–5097 for the spectrum analyzer operating instructions, and the appropriate technical manuals listed in paragraph 286*a* for the remaining test equipments.

b. Test Setup. The test setup in figure 179 and procedures described in paragraph 290 are used to complete the O–371/FRN–20 final testing.

499. Frequency Range and Stability Test

Connect the O–371/FRN–20 as instructed in paragraph 290 and provide constant 115-volt and 230-volt ac input sources.

a. Connect the FR–67/U across the 500-ohm load resistor and measure the frequency with control R902 (fig. 212) at fully clockwise and counterclockwise positions. The minimum frequency range should be 49 to 61 cps inclusive.

b. Vary the 230-volt ac power source between 207 and 253 volts. The output frequency should not vary more than 0.1 cycle.

500. Output Test

Connect the O–371/FRN–20 as instructed in paragraph 290 and provide constant 115-volt and 230-volt ac input sources. Set REGULATOR control R920 (fig. 212) to maximum counterclockwise position and no variable ac voltage applied to pins 5 and 7 of J902 (fig. 175).

a. Connect the AF vtvm across the 500-ohm load resistor. The audio output shall not be less than 1.25 volts ac.

b. Rotate REGULATOR control R920 (fig. 212) to fully clockwise position and apply 115 volts ac to pins 5 and 7 of J902 (fig. 175). The hum level should be more than 40 db below the level indicated in *a* above.

c. Adjust the voltage input to pins 5 and 7 of J902 to 95 volts ac, and set REGULATOR control R902 for 1 volt dc at test point E (fig. 175). The output voltage across the 500-ohm load resistor should be 1.25 volts ac.

d. Adjust the voltage input to pins 5 and 7 of J902 to 115 volts ac. The output voltage across the 500-ohm load resistor should be 0.31 to 0.56 volt ac.

e. Adjust the voltage input to pins 5 and 7 of J902 to 130 volts ac. The output voltage across the 500-ohm load resistor should be 0.125 to 0.375 volt ac.

501. Distortion Test

Connect the O-371/FRN-20 as instructed in paragraph 289 and provide a constant source of 115 volts and 230 volts ac.

a. Connect the spectrum analyzer across the 500-ohm load resistor (fig. 175). Connect the ac vtvm, set for —DC, between pin 2 or 7 of V906 (fig. 211) and chassis.

b. Measure the distortion at 50 and 60 cps frequencies with voltages between 0 and —15 volts dc at pin 2 or 7 of V906 (voltage is varied by adjusting the ac voltage to pins 5 and 7 of J902). The distortion should be less than 10 percent under all conditions.

502. Time Delay and Continuity Test

a. Connect a source of 115 volts ac to pins 8 and 9 of receptacle J902 (fig. 213) with no other external power (115 volts and 230 volts ac) applied. Set the multimeter on the lowest resistance scale and connect it to pins 5 and 6 of receptacle J901 (fig. 213). No continuity should be indicated.

b. Observe the time on a stopwatch or sweep second hand watch and apply 115-volt ac power to pins 8 and 9 of J902. After an elapsed time of 51 to 69 seconds, thermal relay K902 (fig. 213) should operate and after shutting the power off, continuity should be indicated on the multimeter.

Section VII. AUDIO FREQUENCY OSCILLATOR O–373/FRN FINAL TESTING

503. General

Final testing of the O–373/FRN consists of frequency, output, and waveform measurements.

a. Test Equipment. Test equipment required for final testing is the same as that listed for troubleshooting (par. 297). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 290 are used to complete the O–373/FRN final testing.

504. Frequency Test

a. Connect the O–373/FRN as instructed in paragraph 300 and provide a constant 115-volt ac power source. Connect the FR–67/U across the 500-ohm load resistor (fig. 177). Energize the O–373/FRN and allow time for stabilization.

b. Measure the frequency with the FR–67/U. The output frequency should be 1,000 ±100 cps.

505. Output Test

a. Connect the O–373/FRN as instructed in paragraph 299 and provide a constant source of 115 volts ac. Connect the af vtvm across the 500-ohm load resistor (fig. 177).

b. Adjust gain control R15 (fig. 216) for maximum output; the audio output should not be less than 6.8 volts nor greater than 12.1 volts ac.

c. Adjust gain control R15 for an output of 2.9 volts ac. Remove shorting plug P1 from receptacle J3 (fig. 215). Noise should not be less than 40 db below the level obtained in *b* above.

506. Distortion Test

a. Connect the O–373/FRN as instructed in paragraph 300 and provide a constant source of 115 volts ac. Adjust gain control R15 for a 2.9-volt ac output.

b. Connect the oscilloscope across the 500-ohm load resistor (fig. 209) and set the horizontal sweep frequency at approximately 500 cps for a display of two complete cycles.

c. Increase the O–373/FRN output with gain control R15, until the peaks begin to flatten. The output should not be less than 6.8 volts ac.

507. General

Final testing of the monitor consists of signal voltage, phase shift, meter and phase comparator, alarm calibration, audio, and heat run tests.

a. Test Equipment. Test equipment required for final testing the monitor is the same as listed for troubleshooting (par. 308). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 310 are used to complete the monitor final testing.

c. Preliminary Calibration. Connect the monitor as shown in figure 179 and complete the adjustments specified in paragraphs 48 and 49. Use the vor modulator as a signal source adjusted for a minimum signal output of 0.5 volt as shown on the OUTPUT meter. Delete all references to dialing operations and substitute the signal from the vor modulator. Use the vtvm to measure the input level voltage.

508. Signal Voltage Test

a. Measure the voltage with the vtvm between pin 2 of output transformer T2 (fig. 219) and chassis. The voltage should be 30 ±5 volts ac.

b. Measure the voltage with the vtvm between pin 2 of output transformer T1 and chassis. The voltage should be 50 to 75 volts ac.

c. Connect the Y INPUT of the oscilloscope across pin 2 of output transformer T1 and chassis. With the horizontal sweep set at 15 cps, the waveform should be a pure 30-cps sine wave. Readjust capacitor C10 (fig. 219) if necessary.

509. Phase Shift Test

a. Connect the Y INPUT of the oscilloscope between the arm of PHASE ZERO control R72 (fig. 218) and chassis. Connect the X INPUT of the oscilloscope to the 30-cycle REF output of the vor modulator. Adjust the oscilloscope for a suitable external sweep.

b. Starting with position No. 1 on switch S4 (fig. 219) and, PHASE ZERO control R72 centered, rotate the PHASE ANGLE SELECTOR dial of the vor modulator to obtain an in-phase pattern (fig. 181).

c. Observe the oscilloscope pattern for each position of switch S4 by the method described in *b* above; each position shall produce 18 ±1° of phase shift through a full 360°. The extremes of rotation of control R72 should produce a phase shift of 22 ±2°.

Note. Small amplitude changes during the above steps are normal.

510. Meter Deflection and Phase Comparator Test

a. Set switch S4 (fig. 219) to position 5, center PHASE ZERO control R72 (fig. 217), and rotate the vor modulator PHASE ANGLE SELECTOR until the COURSE INDICATOR meter centers (approximately 0°).

b. Rotate control R72 clockwise; meters M1 and M2 should follow to the right. Rotate R72 counterclockwise; both meter needles should follow to the left. Center the needles of both meters with control R72.

c. Test the phase comparator balance adjustment in accordance with instructions given in paragraph 52.

511. Monitor Alarm Test

Perform the tests and check the adjustments of the alarm circuits in accordance with instructions contained in paragraph 54.

512. Calibration, Audio, and Heat Run Test

a. Perform the tests and adjustments of the monitor calibration as instructed in paragraph 53.

b. Set the vor modulator to SPECIFIC SIG and 1,000 cycle, adjust the OUTPUT to 0.2 volt. The audio output at pins 3 and 4 of J2 (fig. 219) shall be at least 4 volts.

c. After all tests prove satisfactory, set PHASE ZERO control R72 to exactly center the needles on meters M1 and M2. Allow the monitor to operate continuously for 24 hours and recheck all steps for radical changes.

513. General

Final testing of the goniometer consists of capacitor phasing and output, motor and drive, and subcarrier output tests. The test equipment listed below is required for goniometer final testing.

Test equipment	Technical manual	Common name
Frequency Meter FR–67/U.	TM 11–2698	Frequency meter.
Spectrum Analyzer TS–723A/U.	TM 11–5097	Spectrum analyzer.
Oscilloscope, DuMont, Type 2559A.		Oscilloscope.
Strobatac, General Radio Corp Model 631.		Strobe light.
RF Wattmeter AN/URM–43A (2 required).	TM 11–5133	Load wattmeter.
Wattmeter Directional Thru-line (Bird Electronic Corp. Model 43).		Line wattmeter.

514. Capacitor Phasing and Output Test

a. Energize all equipment except goniometer motor C/B1 (fig. 228). Check the reflected power percentage (par. 253*b*) at 20° intervals around the goniometer azimuth plate (fig. 30). The rpp must be less than 1 percent throughout 360°.

b. Rotate the azimuth plate to approximately 45° and accurately locate the minimum output point as indicated on the load wattmeter connected to receptacle J5 (fig. 228). The azimuth plate shall indicate 45 ±1°. Check the accuracy at 225° for the same tolerance. Locate the minimums on the load wattmeter connected to receptacle C/J3; minimums should occur at 135° and 315° ±1°.

c. Rotate the azimuth plate to 0°, 90°, 180°, and 270°. The two load wattmeters must indicate the same rf output within 2 percent at all four points.

d. Rotate the azimuth plate to 45°, 135°, 225°, and 315°. Maximums must not be less than 93 percent of the power input to receptacle J4. The minimums must be less than 3.5 percent of the average of the four maximums and equal within 2 percent.

515. Motor and Drive Test

a. Apply 80 volts at 60 cps to goniometer receptacle J6 (fig. 228). The transmitter and the PP–1331/FRN–20 need not be energized; the motor must start and come up to synchronous speed (1,800 rpm, measured with the strobe light).

b. Increase the motor voltage to 115 volts 60 cps and observe the azimuth plate with the strobe light slightly above or below 1,800 rpm. (The plate will appear to rotate slowly.) No wobble should be present in the pulley or plate.

c. The motor must rotate counterclockwise as viewed from the pulley end, and the belt must have approximately 1 inch of free vertical movement.

516. Subcarrier Output Test

a. Energize all of the equipment except goniometer motor C/B1 (fig. 228). Connect the input of the FR–67/U across the 1,000-ohm output resistor (B, fig. 182). Set the azimuth plate to the positions listed below and measure the frequency.

Test	Azimuth plate (degrees)	Frequency (cps)	Tolerance (cps)
A	90	9,960	±50
B	270	9,960	±50
C	0	A plus 480	±24
D	180	A minus 480	±24

Note Test A and B frequencies must not differ by more than 10 cps.

b. Connect the spectrum analyzer across the 1,000-ohm output resistor (B, fig. 182) and measure the output voltage at 0°, 90°, and 180°. The voltage should be 0.4 to 0.75 volt ac.

c. Measure the noise and distortion as instructed in TM 11–5097 for the spectrum analyzer. The noise shall be 40 db below normal output and distortion less than 5 percent (motor not running).

d. Apply 115 volts 60 cps to receptacle J6 (fig. 228) and connect the oscilloscope across 1,000-ohm load resistor (fig. 182). The amplitude modulation should not exceed 5 percent.

Section X. KEYER KY-175/FRN FINAL TESTING

517. General

The final testing of the keyer consists of mechanical and resistance tests.

a. Test Equipment. The multimeter is the only test equipment required for final testing.

b. Test Setup. Connect a 115-volt 60-cps power source to keyer receptacle J501 (fig. 235) when operating tests are required.

518. Mechanical Operating Test

a. Inspect the cycle and code wheels (fig. 236) for the correct code setup as instructed in paragraph 42.

b. Energize the keyer motor and check for smooth operation of the gear train and switches S501 and S502 (fig. 235).

c. With the keyer motor running, check the resistance between terminals of terminal board TB501 listed in chart below.

Function wheel	Roller position (notch)	Terminals	Resistance (ohms)
Cycle	In	4 and 7	Zero.
Cycle	Out	4 and 7	Infinite.
Cycle	Out	5 and 7	Zero.
Cycle	In	5 and 7	Infinite.
Code	In	6 and 7	Zero.
Code	Out	6 and 7	Infinite.
Code	Out	7 and 8	Zero.
Code	In	7 and 8	Infinite.

d. Measure the resistance between the terminals of TB501 listed below with the multimeter.

Terminals	Resistance (ohms)
1 and 2	490 ±10%
2 and 3	100 ±10%
3 and 4	390 ±10%

Section XI. MODULATION ELIMINATOR MX-1843/FRN-20 FINAL TESTING

519. General

Final testing of the modulation eliminator consists of output modulation depth, output stability tests, and meter specifications.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 348). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 351 are used to complete the final testing. Be sure that the transmitting equipment used is operating properly.

520. Output Modulation Depth Test

Connect the equipment as shown in figure 184 and adjust the transmitter output to 40 watts. Set the transmitter MODULATION GAIN control fully clockwise and set the AF oscillator output to provide 50 percent modulation of the transmitter. Connect the oscilloscope to transmitter receptacle J3 (fig. 257).

a. Set SIDE BAND LEVEL control R9 (fig. 31) to produce a 3-watt output from receptacle J3 of the modulation eliminator. Amplitude modulation in the output of the modulation eliminator should not exceed 5 percent when the modulating frequency is varied between 50 and 10,000 cps (transmitter modulation 50 percent).

b. Reduce the AF oscillator output to zero. The hum and noise modulation of the modulation eliminator output should not exceed 1.5 percent.

521. Output Stability Test

a. Adjust the transmitter to provide 40 watts to the modulation eliminator with the MODULATION GAIN control fully clockwise, and the transmitter modulated with 10 kc to a 50-percent modulation level.

b. Rotate SIDE BAND LEVEL control R9 (fig. 31) and the transmitter MODULATION GAIN control (fig. 36) fully counterclockwise. Record the modulation eliminator output power level (number of divisions of vertical oscilloscope deflection). Rotate the transmitter MODULATION GAIN control fully clockwise and record the modulation eliminator output power level.

c. Compute the carrier power level shift as follows:

$$\frac{\text{Modulated (div)}-\text{Unmodulated (div)}}{\text{Unmodulated (div)}}=\text{power level shift}$$

Modulation eliminator power level should not shift more than 10 percent for modulation levels up to 50 percent.

d. Repeat procedures given in *b* and *c* above with SIDE BAND LEVEL control R9 (fig. 31) at fully clockwise position. The modulation eliminator power level should not shift more than 10 percent for modulation levels up to 50 percent.

522. Meter Specifications

Adjust the transmitter to provide 40-watt input to the modulation eliminator, modulated to 50 percent with 10-kc audio. Adjust R9 to produce a 3-watt output from the modulation eliminator. Observe the following meter M1 (fig. 31) indications: LIMITER CATHODE less than 45 ma, FINAL AMP PLATE less than 115 ma, DIODE LEVEL less than 40 volts.

Section XII. POWER SUPPLY PP–1329/FRN–20 FINAL TESTING

523. General

Final testing of the PP–1329/FRN–20 consists of resistance, time delay tests, and voltage measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 357). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 360 are used to complete final testing.

524. Resistance and Time Delay Test

a. With all external connections removed, make the resistance measurements listed in following table with the multimeter. All resistance values must be ±10 percent.

b. Complete the test setup connections shown in figure 186. Note the time and apply 115 and 230 volts ac. After 30 seconds (±20 percent), time delay relay S1401 (fig. 240) should operate.

J1401 terminals (fig. 242)	Resistance (ohms)
H and chassis	0
T and chassis	0
D and L	0. 5
D and F	0. 4
O and R	0. 5
U and V	500
A and B	0. 5
B and C	0. 5
M and N (jumpers 5 and 7 of S1401)	500

525. Voltage Test

a. Measure the dc voltage between fuse F1411 (fig. 239) and chassis; the voltage should be 1,300 volts dc ±10 percent. Use a blocking capacitor (fig. 186) when measuring the ac ripple; it should be less than 0.1 percent of the dc voltage measured.

b. Measure the dc voltage between fuse F1410 and chassis; the voltage should be 500 volts dc ±10 percent. Use a blocking capacitor (fig. 186) when measuring ac ripple; it should be less than 0.1 percent of the dc voltage measured.

Section XIII. POWER SUPPLY PP–1331/FRN–20 FINAL TESTING

526. General

Final testing of the PP–1331/FRN–20 consists of resistance, time delay tests, and voltage measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 366). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup shown in figure 195 and described in paragraph 413 is used to complete final testing. The transmitter is used as a load and must be functioning properly.

527. Resistance and Time Delay Test

a. With all external connections removed, measure the resistances listed below with the multimeter.

TB1 terminals (fig. 243)	Resistance (ohms)
5 and 19	0
3 and 20	0
6 and 21	0
9 and chassis	0
10 and chassis	0
23 and chassis	0
7 and 8	0

TB1 terminals (fig, 243)	Resistance (ohms)
16 and 17	0
1 and 22	0
4 and 26	0
14 and 28 (S1 (fig. 242) closed)	0
13 and 25 (S2 (fig. 242) closed, F2 installed)	0
15 and 24 (S2 closed, F1 installed)	0

b. With 115 volts 60 cps applied and switch S2 closed, time delay relay S3 (fig. 243) should operate 30 seconds (±20 percent) after power is applied.

528. Voltage Test

The *unloaded* and *loaded* test notations pertain to the transmitter *unkeyed* and *keyed* conditions respectively.

a. With the transmitter keyed, the voltage at terminal E1 (fig. 243) should be 500 volts dc or more. The ripple voltage should be less than 0.5 percent of the measured dc voltage. (Use the blocking capacitor when measuring the ac ripple voltage.)

b. With the transmitter keyed, the voltage measured at terminal 7 of terminal board TB1 (fig. 243) should be 225 volts dc or more. The ripple voltage should be less than 2 percent of measured dc voltage. (Use the blocking capacitor when measuring the ac ripple voltage.)

c. The final amplifier bias (terminal 11 of TB1) should be —50 ±10 volts dc unloaded, and —75 ±10 volts dc loaded.

d. The modulator bias (terminal 12 of TB1) should be —100 volts dc ±10 percent unloaded and —25 volts dc ±10 percent loaded. The modulator bias is set by R5 (fig. 242).

e. The voltage at terminal 26 of TB1 should be 12 volts dc unloaded. Voltage loaded should be 10 to 12 volts dc. This voltage is adjusted by varying R9 (fig. 243).

Section XIV. POWER SUPPLY PP–1415/FRN–22 FINAL TESTING

529. General

Final testing of the PP–1415/FRN–22 consists of output voltage measurements at selected tap settings.

a. Test Equipment. Test equipment required is the same as that listed for troubleshooting (par. 376). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 379 are used to complete final testing.

530. Output Voltage Test

Connect the PP–1415/FRN–22 as shown in figure 190 and provide a constant source of 115 volts 60 cps input. Measure the output voltage at terminals 1 and 2 of TB1202 (fig. 244) with the multimeter; use the tap positions of terminal board TB1201 listed below. Adjust the load resistor (fig. 190) to maintain a constant output current of 3.5 amperes dc at all tap positions.

Tap position	Output (volts dc)
1	More than 17.
2	More than 14.5.
3	More than 12.
4	More than 10.5.

Section XV. RADIO SET CONTROL C–1739/FRN–20 FINAL TESTING

531. General

Final testing of the remote control unit consists of operation and continuity measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 384). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 387 are used to complete the final testing.

532. Testing Procedures

Complete the tests described in paragraph 388*a* and *b* in the order listed. Omit the procedures in paragraph 388*c*.

Section XVI. RADIO SET CONTROL C–1738/FRN–20 FINAL TESTING

533. General

Final testing of the C–1738/FRN–20 consists of operation and continuity measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 393). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 395 are used to complete the final testing.

534. Testing Procedures

Complete the tests described in paragraph 397*a* and *b* in the order listed. Omit the procedures in paragraph 397*c*.

Section XVII. RADIO SET TRANSFER CONTROL C–1840/FRN–22 FINAL TESTING

535. General

Final testing of the C–1840/FRN–22 consists of operation and continuity measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 402). Refer to the appropriate technical manuals for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 405 are used to complete the final testing.

536. Testing Procedures

Complete the tests described in paragraph 406*a* and *b* in the order listed. Omit the procedures in paragraph 406*c*.

Section XVIII. RADIO TRANSMITTER T–573/FRN–20 FINAL TESTING

537. General

Final testing of the transmitter consists of output, meter specifications, modulation, and stability measurements.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 410), with the addition of the spectrum analyzer. Refer to the appropriate technical manuals for instructions on the use of the test equipment (the spectrum analyzer manual is TM 11–5097).

b. Test Setup. The test setup and procedures described in paragraph 413 are used to complete final testing. Be sure that the PP–1331/FRN–20 is functioning properly and that the transmitter is tuned in accordance with instructions in paragraph 39.

538. Output Test

Connect the transmitter as shown in figure 195 to a source of 115 volts 60 cps. Adjust EXCITATION CONTROL R8 (fig. 36) for exactly 10 ma on the meter with the meter switch set to FINAL AMP GRID. Set the modulation to 100 percent with a 1,000-cps input signal and the MODULATION GAIN control fully clockwise.

a. The transmitter power output should not be less than 50 nor more than 60 watts. The audio input to the modulator should not exceed .5 volt ac.

b. The front panel meter indications listed below are maximum values in milliamperes.

Switch S2 position	Meter reading
OSC PLATE	15
1ST AMP GRID	2
1ST AMP PLATE	40
2ND AMP GRID	4
2ND AMP PLATE	60
FINAL AMP GRID	10 (exact)
FINAL AMP SCRN	30
FINAL AMP TOTAL	225
MOD TOTAL (unmodulated)	55
MOD TOTAL (modulated)	225

539. Modulation and Stability Test

Connect the transmitter as shown in figure 195 to a source of 115 volts 60 cps. Adjust EXCITATION CONTROL R8 (fig. 36) for exactly 10 ma on the meter with the meter switch set to FINAL AMP GRID, and the MODULATION GAIN control fully clockwise.

a. Measure the audio voltage required to maintain 100 percent modulation from 250 to 11,000 cps. The input required should not exceed 0.5 volt ac.

b. The audio input required to maintain 100 percent modulation should not vary more than 4 db in the frequency range of 500 to 700 cps.

c. The audio input required to maintain 100 percent modulation should not exceed ±0.2 db in the frequency range of 9,000 to 11,000 cps.

d. The noise and hum level should be at least 40 db below the level required for 100 percent modulation at 1,000 cps.

e. Distortion should not exceed 10 percent at 1,000 cps with modulation set at 90 percent. Measure distortion with the spectrum analyzer connected to transmitter test receptacle J3 (fig. 257).

f. The transmitter output frequency should be ±.01 percent of the assigned frequency as measured with the AN/URM–32.

Section XIX. RELAY ASSEMBLY RE–247/FRN–22 FINAL TESTING

540. General

Final testing of the RE–247/FRN–22 consists of continuity tests by voltage and continuity methods.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 421). Refer to the appropriate technical manual for instructions on the use of the test equipment.

b. Test Setup. The test set up (fig. 197) and procedures described in paragraph 423 are used to complete final testing.

541. Testing Procedures

Apply 115 volts ac to receptacles J403 and J404 (fig. 263) continuously unless otherwise instructed.

a. Adjust the 12-volt dc power supply to apply 9 volts dc to pins 2 and 3 of receptacle J401 (fig. 262) with switch S401 in the 460A position. Relay O 401 should be energized; there should be continuity between pins 9 and 10 of receptacle J402 and 115 volts ac between pins 3 and 4 of J402.

b. Move switch S401 to TEST position, S402 to ON, S403 to 460A, and S404 to OFF. Relays O 401 and O 402 should energize when 9 volts dc is applied to terminals 1 and 2 of receptacle J401, and 115 volts ac should be measured between pins 1 and 2 of J402.

c. Set S401 to 460A, S402 to OFF; relay O 402 should energize when 9 volts dc is applied to pins 2 and 4 of J401.

d. Apply 9 volts dc to pins 2 and 5 of receptacle J401; relay O 403 should energize; there should be continuity between pins 11 and 12 of J402, and 115 volts ac between pins 7 and 8 of J402.

e. Set switch S403 to the TEST position, and S404 to ON; apply 9 volts dc to pins 1 and 2 of receptacle J401. Relays O 403 and O 404 should energize, and 115 volts ac should be measured between pins 5 and 6 of J402.

f. Set switch S403 to the 460A position, and S404 to OFF. Apply 9 volts dc to pins 1 and 6 of J401; relay O 404 should energize.

Section XX. RELAY ASSEMBLY RE–248/FRN–22 FINAL TESTING

542. General

Final testing of the RE–248/FRN–22 consists of continuity checks by voltage and continuity methods.

a. Test Equipment. Test equipment for final testing is the same as that listed for troubleshooting (par. 428). Refer to the appropriate technical manual for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedures described in paragraph 431 are used to complete final testing.

543. Testing Procedures

Connect the fabricated cables (fig. 198) to receptacles J301, J303, and J304 (fig. 278) and adjust the dc power supply to provide an output voltage of 9.5 volts dc.

a. Apply 9.5 volts dc to pins 8 and 24 of receptacle J301 (fig. 266); relay O 301 should energize and continuity should be indicated between the following pins of receptacle J301: 1 and 19, 8 and 23, and 21 and 24.

b. Apply 9.5 volts dc across pins 17 and 18 of receptacle J301; relay O 302 should energize and continuity should be indicated between the following pins of receptacle J301: 1 and 2, 1 and 7, and 16 and 24. Continuity should also be indicated between pin 24 and J 301 and pin 5 of J303.

c. Apply 9.5 volts dc across pins 5 and 22 of receptacle J301; relay O 303 should energize and continuity should be indicated between the pins listed below.

Receptacle J301	Receptacle and pin
Pin 13	J304 pin 1.
Pin 12	J305 pin 2.
Pin 11	J304 pin 3.
Pin 10	J304 pin 4.
Pin 9	J304 pin 5.
Pin 6	J304 pin 6.

d. Apply 9.5 volts dc across pin 5 of receptacle J301 and pin 7 of J302; relay O 303 energizes and deenergizes when switch S301 is positioned ON and OFF.

e. Disconnect the dc power supply and check continuity between the pairs of test points listed below.

Test point one	Test point two
J301 pin 19	and J301 pin 20.
J301 pin 16	and J301 pin 24.
J301 pin 13	and J303 pin 1.
J301 pin 12	and J303 pin 2.
J301 pin 11	and J303 pin 3.
J301 pin 10	and J303 pin 4.
J301 pin 9	and J303 pin 5.
J301 pin 6	and J303 pin 6.

Section XXI. VOLTAGE REGULATOR CN–358/FRN–22 FINAL TESTING

544. General

Final testing of the voltage regulator consists of a test of regulation under varying input voltages, and an output voltage range test.

a. Test Equipment. Test equipment required for final testing is the same as that listed for troubleshooting (par. 436). Refer to the appropriate technical manual for instructions on the use of the test equipment.

b. Test Setup. The test setup and procedure described in paragraph 439 are used to complete the final testing. Data are also included for final testing in the event that an ac load panel is made available for testing.

545. Testing Procedures

The complete omnirange set should be used for final testing unless an ac load panel is made available.

a. With the voltage regulator connected as shown in figure 199, apply 230 volts 60 cps to terminals 1 and 2 of terminal board TB1 (fig. 269) and complete the following procedures:

(1) Dial 10 on the C–1738/FRN–20 and turn off the monitor. Adjust OUTPUT VOLTAGE CONTROL R12 (fig. 268) to both extremes. The voltage should vary between 220 and 240 volts as indicated on meter M1.

(2) Set R12 for an indication on M1 of exactly 230 volts ac, dial 9 and note the voltage. Dial 8 and again note the voltage. The voltage should be 230 volts ac ±1 percent with no oscillating or hunting.

(3) Vary the input voltage to the voltage regulator from 195 to 255 volts ac. The output should remain at 230 volts ac ±1 percent.

b. If an ac load panel is available, connect a 195- to 255-volt, 60-cps source to terminals 1 and 2 of terminal board TB1 and the load panel to terminals 3 and 4. Complete the following procedures:

(1) Apply a resistive load to cause 25 amperes ac to flow, and adjust the voltage control to both extremes. The voltage range should be 220 to 240 volts ac or more, with 230 volts ac applied to the input.

(2) Adjust OUTPUT VOLTAGE CONTROL R12 for exactly 230 volts ac output, vary the input voltage from 195 to 255 volts ac. The output voltage should remain at 230 volts ac ±1 percent (with 25-ampere resistive load).

(3) Adjust OUTPUT VOLTAGE CONTROL R12 for exactly 230 volts ac output with 230 volts input and a 25-ampere resistive load. Vary the load between 10 and 32 amperes; the output voltage should remain at 230 volts ac ±1 percent.

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

546. Disassembly of Equipment

The following instructions are recommended as a guide for preparing Radio Transmitting Set AN/FRN-22A for shipment and storage:

***Warning:* Turn off all circuit breakers at the antenna pedestal and disconnect powerline service to the omnirange site.**

a. Remote Control Site.

(1) Disconnect cable W22 (fig. 16) from the 115-volt ac source. Coil the cord and secure it inside the cabinet.

(2) Disconnect the telephone line and ground wire from terminal board E501 (fig. 16).

(3) Unplug the microphone and handset and remove the handset bracket. Remount the bracket inside the cabinet.

b. Antenna Group AN/FRA-14.

(1) Disconnect plugs P10 and P11 (fig. 16), remove the screws that fasten the AN/FRA-14 to the pole, and remove it from the pole. Place the attaching parts in a bag and attach them to the AN/FRA-14.

(2) Remove the antenna from the AN/FRA-14 (fig. 9) and replace the nuts on the insulators and bracket.

c. Cables.

***Warning:* Be sure that the 230-volt ac line is deenergized at the entrance to the omnirange site.**

(1) In the CY-1897/FRN-22, disconnect plugs P401 and P9 (fig. 16) at the RE-247/FRN-22 and the monitor.

(2) Disconnect the external control cabinet wiring at terminal boards TB801, TB-802, TB803, TB804, and TB805 (fig. 16). Remove the coupling nuts from the conduit fittings and remove the wiring from the CY-1897/FRN-22.

(3) Disconnect the external wiring to the CY-2274/FRN-22A at terminal boards TB1903, TB1904, TB1905, TB1906, TB-1907, TB1908, and TB1909. Disconnect wires from terminals E1901, E1902, E1905, E1906, and cabinet ground.

(4) Remove the conduit coupling nuts, conduit and wiring from the cabinet.

(5) Disconnect coaxial cables W13, W14, and W15 (fig. 16) at the CY-1899/FRN-22 (equipment No. 1) and at the antenna relay assembly.

(6) Disconnect coaxial cables W16, W17, and W18 at the CY-1899/FRN-22 (equipment No. 2) and at the antenna relay assembly.

(7) Disconnect the external wiring to the CY-1899/FRN-22 No. 1 and No. 2 cabinets, and from terminal boards TB1801, TB1802, terminals E1801, E1802, and the cabinet ground (fig. 16). Remove the conduit coupling nuts and wiring from the cabinet.

d. Removal of Components.

(1) Disconnect all connectors and terminal boards of each component in all four cabinets (fig. 16). Be sure that the wiring is clear of the components.

(2) Remove the cabinet front trim strips and, starting with the uppermost component in each cabinet, remove the components.

(3) Disconnect the cabinet blower plugs and remove the plugs from the cords. Replace the plug in the cabinet receptacles.

(4) Remove the blower assembly from the outside of the door (fig. 35), and reinstall it on the inside of the door.

(5) Remove the components and cabinets from the site to the storage area.

e. Removal of Antenna AT–669/FRN–22.

(1) Disconnect coaxial cables W2, W3, W4, and W5 from the antenna relay assembly. Disconnect the obstruction lights cable at circuit breaker K1006 and antenna heaters from circuit breaker K1002 (fig. 16). Remove the wires from the circuit breaker box.

(2) Loosen the locknuts and setscrews at the top of the pedestal (fig. 4). Remove the antenna carefully while an assistant guides the cables through the hole in the pedestal. Remove the obstruction lights lenses and bulbs.

(3) Roll the cables and place them inside the antenna base tube.

f. Shelter Disassembly.

(1) Disconnect the shelter blower wiring and remove the blower and vent (figs. 6 and 7).

(2) Remove one half of the shelter roof at a time by removing the attaching parts at the wall first. Remove the roof stiffeners (fig. 5).

(3) Remove the wall sections, starting with the section to the left of the door and proceeding in a clockwise direction (figs. 4 and 5).

(4) Remove the pedestal and secure the cables to the pedestal. Disassemble the shelter skid (fig. 3).

(5) Remove the earth ground rod and underground cables. Clean and coil all cabling.

547. Repacking for Shipment or Limited Storage

a. The procedure for repackaging for shipment or limited storage depends on the available material and the conditions under which the equipment is to be shipped. The reverse order of the instruction in paragraph 3, and the information in figure 2 will serve as guides for repackaging. Appendix II contains a complete table of packaging data.

b. Whenever practicable, place a dehydrating agent, such as silica gel, inside the antenna and seal the lower end. The same procedure may be used on all units by wrapping them in corrugated cardboard and sealing them in waterproof barrier paper.

Section II. DEMOLITION OF MATERIEL

548. Authority for Demolition

Demolition of the equipment will be accomplished only upon the order of the commander. The destruction procedures outlined in paragraph 549 will be used to prevent further use of the equipment.

549. Methods of Destruction

a. Smash. Smash controls, tubes, coils, switches, capacitors, motors, and meters; use sledges, axes, handaxes, pickaxes, hammers, or crowbars.

b. Cut. Cut all wiring and coaxial cables; use axes, handaxes, or machetes.

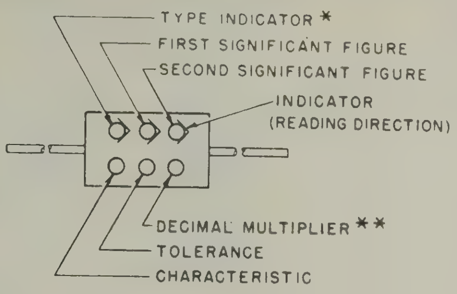
c. Burn. Burn cords and technical manuals; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

d. Bend. Bend panels and cabinets.

e. Explode. Place explosives inside the antenna; use firearms or TNT.

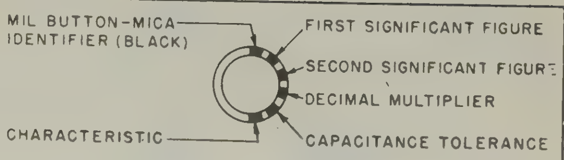
f. Dispose. Bury or scatter the destroyed parts in slit trenches or foxholes, or throw them into streams.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)

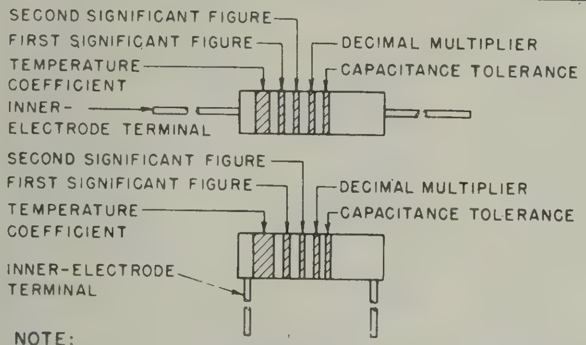


* BLACK DOT: MICA DIELECTRIC
SILVER DOT: PAPER DIELECTRIC
**INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)

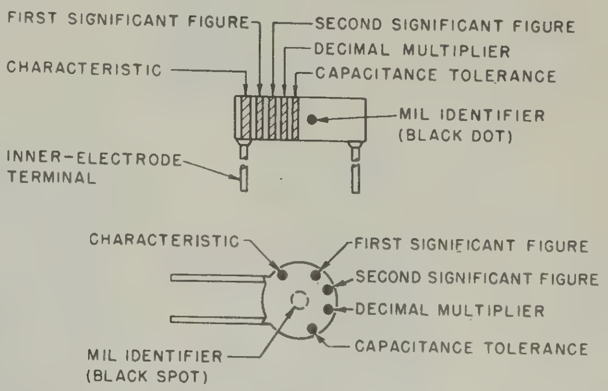


BUTTON-MICA (CB)



NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS; TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)



NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS; CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, −20%.

CERAMIC-GENERAL PURPOSE (CK)

CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE 2					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		−30
RED	2	100	2	C	H		X	2		2	2		−80
ORANGE	3	1,000	3	D	J	D			30				−150
YELLOW	4	10,000	4	E	P								−220
GREEN	5		5	F	R						5	0.5	−330
BLUE	6		6		S								−470
PURPLE (VIOLET)	7		7		T	W							−750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	−330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

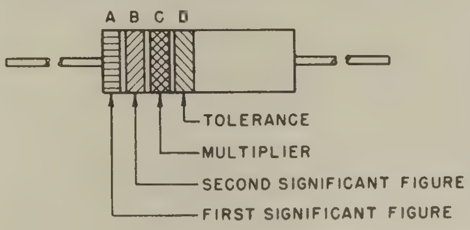
1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

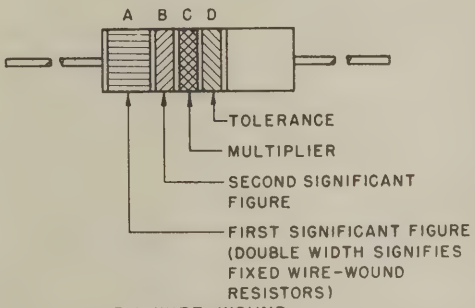
Figure 272. MIL-STD capacitor color code markings.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)

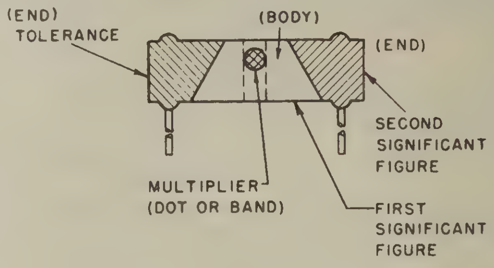


RC-COMPOSITION

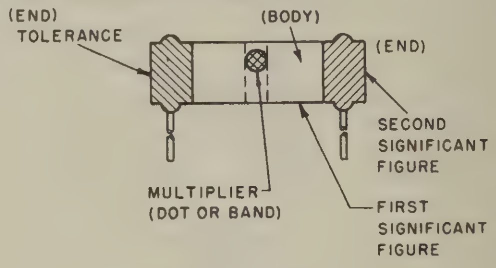

A B C D
TOLERANCE
MULTIPLIER
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE (DOUBLE WIDTH SIGNIFIES FIXED WIRE-WOUND RESISTORS)

RU-WIRE-WOUND

RADIAL-LEAD RESISTORS (UNINSULATED)



RZ-COMPOSITION



RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

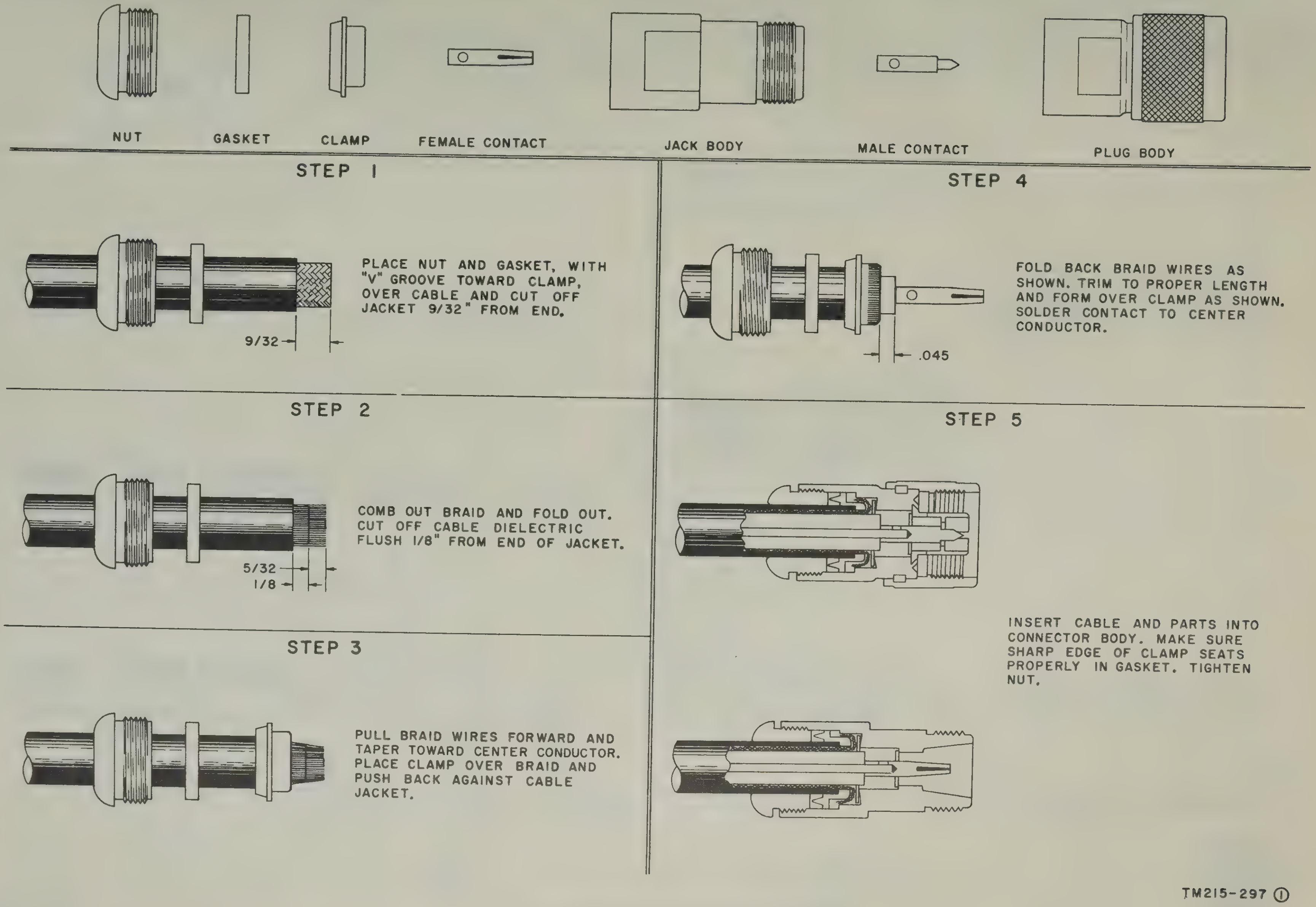
*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R1

Figure 273. MIL-STD resistor color code markings.



STEP 1

PLACE NUT AND GASKET, WITH "V" GROOVE TOWARD CLAMP, OVER CABLE AND CUT OFF JACKET 9/32" FROM END.

STEP 2

COMB OUT BRAID AND FOLD OUT. CUT OFF CABLE DIELECTRIC FLUSH 1/8" FROM END OF JACKET.

STEP 3

PULL BRAID WIRES FORWARD AND TAPER TOWARD CENTER CONDUCTOR. PLACE CLAMP OVER BRAID AND PUSH BACK AGAINST CABLE JACKET.

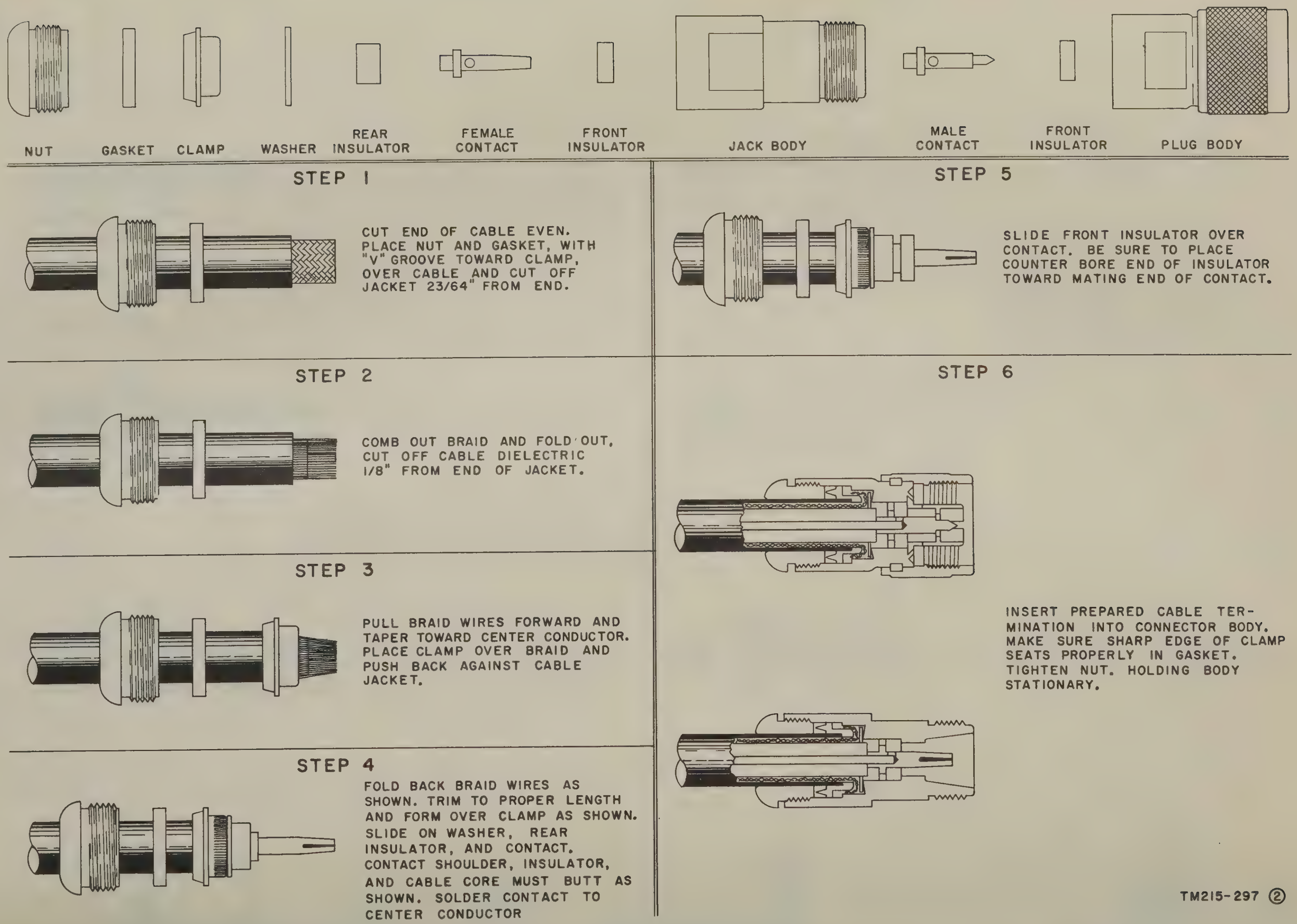
STEP 4

FOLD BACK BRAID WIRES AS SHOWN. TRIM TO PROPER LENGTH AND FORM OVER CLAMP AS SHOWN. SOLDER CONTACT TO CENTER CONDUCTOR.

STEP 5

INSERT CABLE AND PARTS INTO CONNECTOR BODY. MAKE SURE SHARP EDGE OF CLAMP SEATS PROPERLY IN GASKET. TIGHTEN NUT.

Figure 274. Coaxial cable assembly instructions.



STEP 1

CUT END OF CABLE EVEN. PLACE NUT AND GASKET, WITH "V" GROOVE TOWARD CLAMP, OVER CABLE AND CUT OFF JACKET 23/64" FROM END.

STEP 2

COMB OUT BRAID AND FOLD OUT, CUT OFF CABLE DIELECTRIC 1/8" FROM END OF JACKET.

STEP 3

PULL BRAID WIRES FORWARD AND TAPER TOWARD CENTER CONDUCTOR. PLACE CLAMP OVER BRAID AND PUSH BACK AGAINST CABLE JACKET.

STEP 4

FOLD BACK BRAID WIRES AS SHOWN. TRIM TO PROPER LENGTH AND FORM OVER CLAMP AS SHOWN. SLIDE ON WASHER, REAR INSULATOR, AND CONTACT. CONTACT SHOULDER, INSULATOR, AND CABLE CORE MUST BUTT AS SHOWN. SOLDER CONTACT TO CENTER CONDUCTOR

STEP 5

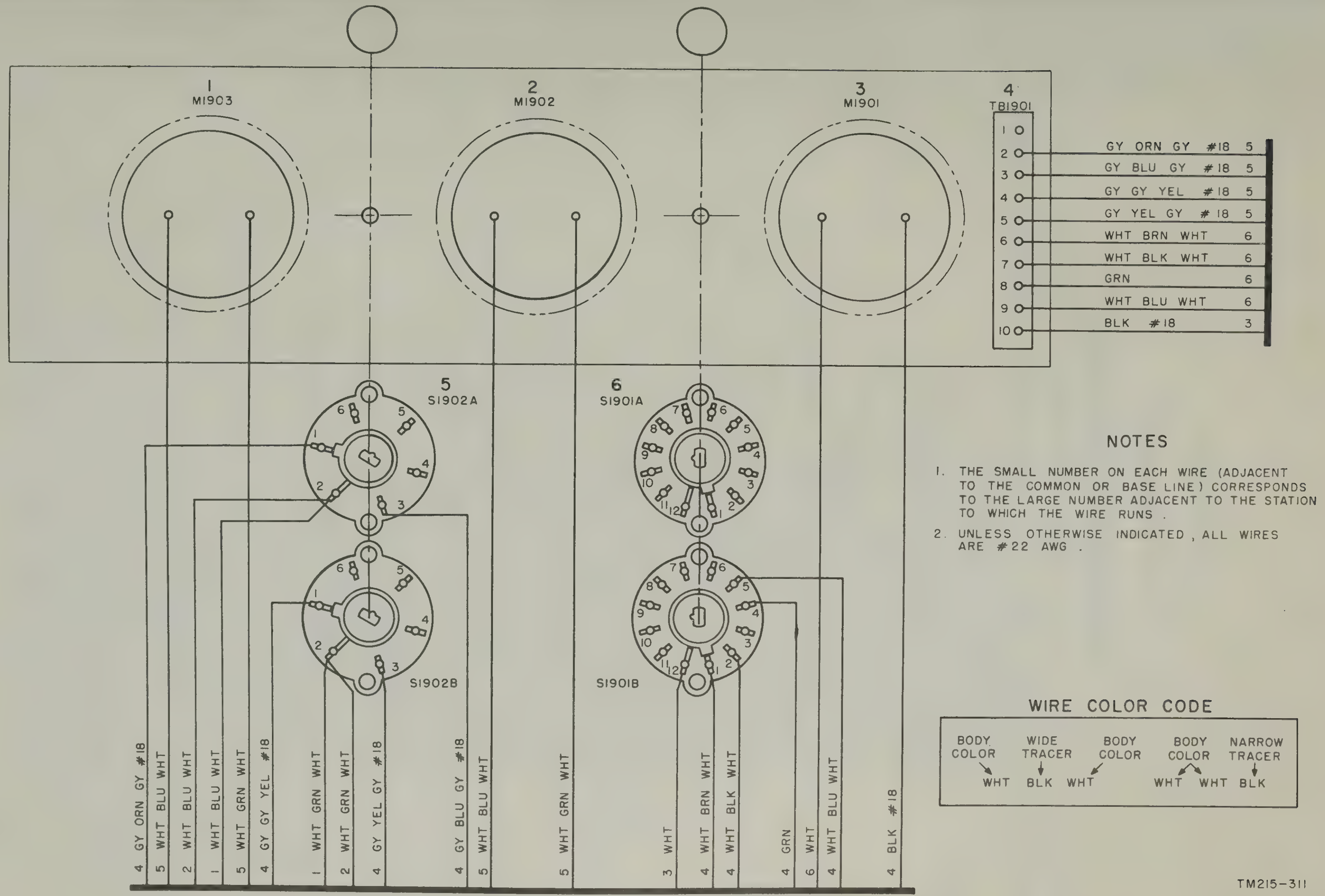
SLIDE FRONT INSULATOR OVER CONTACT. BE SURE TO PLACE COUNTER BORE END OF INSULATOR TOWARD MATING END OF CONTACT.

STEP 6

INSERT PREPARED CABLE TERMINATION INTO CONNECTOR BODY. MAKE SURE SHARP EDGE OF CLAMP SEATS PROPERLY IN GASKET. TIGHTEN NUT. HOLDING BODY STATIONARY.

Figure 274—Continued.

(*Figures 275 to 304 contained in separate envelope.*)



NOTES

1. THE SMALL NUMBER ON EACH WIRE (ADJACENT TO THE COMMON OR BASE LINE) CORRESPONDS TO THE LARGE NUMBER ADJACENT TO THE STATION TO WHICH THE WIRE RUNS .
2. UNLESS OTHERWISE INDICATED , ALL WIRES ARE #22 AWG .

Figure 305. Indicator Panel SB–830/FRN–22A, wiring diagram.

(Figures 306 to 317 contained in separate envelope.)

APPENDIX I

REFERENCE DESIGNATIONS

Following is a list of references, together with designations that are explained in paragraph 1.

1–99	Power Supply PP–1331/FRN–20
A/1–A/99	Radio Transmitter T–573/FRN–20
B/1–B/99	Modulation Eliminator MX–1843/FRN–20
C/1–C/99	Electrical Goniometer GO–12/FRN–20
D/1–D/99	Antenna AT–669/FRN–22
E/1–E/99	Audio Frequency Oscillator O–373/FRN
F/1–F/99	Course Monitor MX–1837/FRN–20
G/1–G/99	Audio Frequency Amplifier AM–1246/FRN–20
H/1–H/99	Antenna Group AN/FRA–14
J/1–J/99	Audio Frequency Amplifier AM–1247/FRN–20
K/1–K/99	Voltage Regulator CN–358/FRN–22
Q/1–Q/99	Electrical Equipment Cabinet CY–1826/FRN–20
201–299	Radio Set Control C–1738/FRN–20
301–399	Relay Assembly RE–248/FRN–22
401–499	Relay Assembly RE–247/FRN–22
501–599	Radio Set Control C–1739/FRN–20
L/501–L/599	Keyer KY–175/FRN
601–699	Radio Set Transfer Control C–1840/FRN–22
801–899	Electrical Equipment Cabinet CY–1897/FRN–22
901–999	Audio Frequency Oscillator O–371/FRN–20
1001–1099	Aircraft Obstruction Marker Light MX–1919/FRN–22
M/1001–M/1099	Propeller Ventilating Fan HD–244/FRN–22
N/1001–N/1099	Antenna pedestal, part of Electrical Equipment Shelter S–120/FRN–22
1201–1299	Power Supply PP–1415/FRN–22
1401–1499	Power Supply PP–1329/FRN–20
1801–1899	Electrical Equipment Cabinet CY–1899/FRN–22
1901–1999	Indicator Panel SB–830/FRN–22A
P/1901–P/1999	Electrical Equipment Cabinet CY–2274/FRN–22A

APPENDIX II

PACKAGING DATA

Box No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)	Contents of box	
						Quantity	Item
1 of 26	27	39	87	52	475	1	Electrical Equipment Cabinet CY–1897/FRN–22 consisting of:
						1	Wired equipment cabinet.
						1	Blank panel (5¼ in. x 19 in. x ⅛ in.).
						1	Blank panel (3½ in. x 19 in. x ⅛ in.).
						1	Handset mounting bracket.
						2	Trim strips.
						1	Envelope of speed nuts.
						1	Envelope of No. 10 x ⅝ in. sheet metal screws.
						1	Envelope of trim strip clips.
						1	Electrical lead (W23).
						4	Power cable assembly (W6, W9, W11, W12).
						1	Power cable assembly (W8).
						2	TM 11–5825–205–35.
2 of 26	27	39	87	52	475	1	Electrical Equipment Cabinet CY–1899/FRN–22 consisting of:
						1	Wired equipment cabinet.
						1	Blank panel (3½ in. x 19 in. x ⅛ in.).
						2	Trim strips.
						1	Envelope of speed nuts.
						1	Envelope of No. 10 x ⅝ in. sheet metal screws.
						1	Envelope of trim strip clips.
3 of 26	27	39	87	52	475	1	Electrical Equipment Cabinet CY–1899/FRN–22 consisting of:
						1	Wired equipment cabinet.
						1	Blank panel (3½ in. x 19 in. x ⅛ in.).
						2	Trim strips.
						1	Envelope of speed nuts.
						1	Envelope of No. 10 x ⅝ in. sheet metal screws.
						1	Envelope of trim strip clips.
4 of 26	27	39	87	52	475	1	Electrical Equipment Cabinet CY–2274/FRN–22A consisting of:
						1	Wired equipment cabinet.
						1	Blank panel (24$\frac{7}{16}$ in. x 19 in. x ⅛ in.).
						1	Blank panel (5¼ in. x 19 in. x ⅛ in.).
						2	Trim strips.
						1	Envelope of speed nuts.
						1	Envelope of No. 10 x ⅝ in. sheet metal screws.
						1	Envelope of trim strip clips.
						1	Indicator Panel SB–830/FRN–22A.
5 of 26	16	20	29	5. 4	111	1	Electrical Equipment Cabinet CY–1826/FRN–20 consisting of:
						1	Equipment cabinet.
						1	Handset mounting bracket.
						1	Radio Set Control C–1739/FRN–20.
						1	Audio Frequency Amplifier AM–1247/FRN–20.
						1	Microphone head.
						1	Microphone stand.
						2	Handset (one handset is part of Electrical Equipment Cabinet CY–1897/FRN–22).
						1	Power cable assembly (W22).
						1	Special-purpose cable assembly (W20).
						1	Wiring harness (W21).

Box No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)	Contents of box	
						Quantity	Item
6 of 26	15	24	38	8	142	1	Power Supply PP–1415/FRN–22.
						1	Radio Set Control C–1738/FRN–20.
						1	Radio Set Transfer Control C–1840/FRN–22.
						1	Relay Assembly RE–247/FRN–22.
						1	Relay Assembly RE–248/FRN–22.
7 of 26	16	17	24	4	83	1	Course Monitor MX–1837/FRN–20.
8 of 26	10	16	25	2.1	46	2	Audio Frequency Oscillator O–373/FRN.
9 of 26	26	24	135	49	400	1	Aircraft Obstruction Marker Light MX–1919/FRN–22 consisting of:
						1	Obstruction light fixture (mounted on Antenna AT–669/FRN–22).
						2	Traffic signal bulb (100 watt).
						2	Red glass light lens.
						1	Antenna AT–669/FRN–22.
						1	Antenna Group AN/FRA–14 consisting of:
						1	Detector housing.
						1	Folded dipole antenna.
						2	Keyer KY–175/FRN.
						2	Light bulb for antenna pedestal (100 watt).
10 of 26	20	23	26	7	165	1	Voltage Regulator CN–358/FRN–22.
						2	Envelope of mounting hardware.
11 of 26	19	22	34	8.2	145	2	Electrical Goniometer GO–12/FRN–20.
						2	Pulley wheel.
12 of 26	13	24	26	4.3	90	2	Modulation Eliminator MX–1843/FRN–20.
						2	RF cable assembly (W1).
13 of 26	13	23	26	4.5	85	2	Radio Transmitter T–573/FRN–20.
14 of 26	18	27	34	10	176	1	Power Supply PP–1331/FRN–20.
15 of 26	18	27	34	10	176	1	Power Supply PP–1331/FRN–20.
16 of 26	22	32	36	14.6	275	1	Power Supply PP–1329/FRN–20.
17 of 26	22	32	36	14.6	275	1	Power Supply PP–1329/FRN–20.
18 of 26	13	24	26	4.3	83	2	Audio Frequency Oscillator O–371/FRN–20.
19 of 26	13	24	26	4.3	103	2	Audio Frequency Amplifier AM–1246/FRN–26.
20 of 26	39	39	41	38	344	1	Propeller Ventilating Fan HD–244/FRN–22 consisting of:
						1	Blower and housing.
						2	Louvered exhaust vents.
						2	Air filters.
						1	Upper mounting flange for blower housing.
						1	Bag of mounting hardware.
						1	Roll of rubber strip gasket.
21 of 26	61	8	118	33	445	2	Roof section (part of Electrical Equipment Shelter S–120/FRN–22).
						6	Plywood sections (part of Platform Skid MX–1918/FRN–22) consisting of:
						2	Plywood section ¾ in. x 48 in. x 96 in.
						2	Plywood section ¾ in. x 24 in. x 48 in.
						1	Plywood section ¾ in. x 24 in. x 96 in.
						1	Plywood section ¾ in. x 24 in. x 24 in.
22 of 26	16	19	121	21	615	--------	Precut wood building material (part of Platform Skid MX–1918/FRN–22) consisting of:
						2	Side plate 2 in. x 10 in. x 120 in.
						10	Joist 2 in. x 8 in. x 116¾ in.
						1	Stringer 2 in. x 8 in. x 120 in.
						2	Runner 4 in. x 4 in. x 120 in.
						8	Spreader block 2 in. x 8 in. x 14⅜ in.
						4	Spreader block 2 in. x 8 in. x 13 9/16 in.
						4	Spreader block 2 in. x 8 in. x 9 9/16 in.

APPENDIX II—Continued

Box No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)	Contents of box	
						Quantity	Item
23 of 26	43	62	84	130	1, 165	--------	Shelter construction material (part of Electrical Equipmen Shelter S–120/FRN–22) consisting of:
						6	Wall sections.
						12	Roof stiffeners.
						6	Channel strips.
						1	Caulking gun.
						2	Tube of caulking compound.
						1	Ground rod (6 ft).
						1	Box of gasket material.
						7	Box of ½–13 x 1 in. bolts (100 in box).
						7	Box of ½–13 x ⅝ in. sq nuts (100 in box).
						1	Bag of 710 recessed washers and ring gaskets.
						1	Bag of ½ in. x 1½ in. lag screws.
						1	Bag of ⅜–16 x 1 in. bolts and nuts.
						1	Envelope of flat washers (9/16 in. id x 1⅜ in. od).
							The following items are part of Platform Skid MX–1918/FRN–22:
						4	Angle bracket.
						1	Box of ½–13 x 3 in. bolts, nuts, and washers.
						1	Box of 10d nails.
						1	Box of 20d nails.
24 of 26	31	30	87	47	527	1	Antenna Pedestal (part of Electrical Equipment Shelter S–120/FRN–22).
25 of 26	12	26	27	4. 8	80	1	RF cable assembly (W5).
						1	RF cable assembly (W7).
						1	Power cable assembly (W10).
						6	RF cable assembly (W13, W14, W15, W16, W17, W18).
						1	Branched wiring harness (W19).
						2	Oilcan (1 ounce).
26 of 26	18	26	27	7. 3	75		Running spares.

Total weight 7,506

GLOSSARY

Section I. ABBREVIATIONS

ac	alternating current
agc	automatic gain control
amp	ampere
AWG	American Wire Gage
cont	continue, continued
cps	cycles per second
db	decibel (0 db level is 1.73 volts across 500 ohms)
dc	direct current
F	Fahrenheit
fm	frequency modulation, or frequency modulated
id	inside diameter
kva	kilovolt-amperes
lb	pound (weight)
ma	milliamperes
mc	megacycles
mcw	modulated continuous wave
MWO	Modification work order
NC	Normally closed
NO	Normally open
od	outside diameter
rf	radiofrequency
rpm	revolutions per minute
rpp	reflected power percentage
swr	standing-wave ratio
term.	terminal
thru	through
v	volt, or volts
vhf	very high frequency
VOR	very high frequency omnidirectional radio range
vswr	voltage standing-wave ratio
vtvm	vacuum-tube voltmeter
w	watt, or watts

Section II. DEFINITIONS OF UNUSUAL TERMS

Alarm—An indication by lights or buzzer of a malfunction of the omnirange equipment preventing transmission of the normal navigational signal.

Antenna loading—The amount of output power absorbed by the antenna as indicated by the final amplifier plate current.

Antenna loading fins—Sheet metal strips attached to the edges of the four antenna slots, and folded back from them. They provide capacitive loading and tuning of their respective slots.

Antenna slot—The radiating portion of the antenna assembly, consisting of four narrow vertical slots cut out of the metal wall of the antenna cylinder, and spaced at 90° intervals around its circumference.

Automatic gain control—A method of holding the electrical output of a unit constant by rectifying a portion of the output voltage for use as a control bias and applying this bias to a controlled amplifier stage.

Azimuth—The angle, in a horizontal plane, to an object, measured at the observation point in degrees clockwise from magnetic North.

Balun—An electrical device, actually a transformer, designed to change a line connection from a balanced condition to an unbalanced condition, at a fixed impedance ratio (usually 4 to 1).

Buck-boost transformer—A transformer yielding controllable variation in output voltage, by changeable connection of the transformer primary so that a control voltage decreases (bucks) or increases (boosts) the normal input voltage.

Code wheel—A motor-driven, segmented wheel which actuates a switch that interrupts an audible tone to form the station call letters.

Cone of confusion—The area above an omnirange antenna, shaped somewhat like an inverted cone, where the combination of horizontally and vertically polarized antenna radiations interrupt navigational courses and provide station location information.

Contact potential—The potential produced by the current flow in a vacuum-tube diode circuit caused by random bombardment of the plate with heater power only.

Course alignment—The alignment between the 0° course projected by the omnirange set and magnetic North.

Course bending—A radial which does not maintain a straight-line projection but bends gradually to form an arc.

Course discrepancy—The difference in course alignment between transmitting equipments.

Course roughness—The deviation of a radial from a straight line, in which the degree of error is not so important as the rate of change.

Course scalloping—The rhythmic excursions of a radial either side of a straight line.

Course sensitivity—The difference in the number of degrees required to cause full-scale deflection left and right from the center on a specific radial.

Course width—The number of degrees between full-scale left deflection and full-scale right deflection during flight check at a fixed radius from the site.

Cycle wheel—A motor-driven, segmented wheel that actuates a switch to set the rate at which station call-letter transmission will be repeated.

Flight check—A procedure for testing the navigational information transmitted by the omnirange set, using a specially equipped aircraft.

Frequency-modulated subcarrier—The subcarrier center frequency of 9,960 cps when the frequency is changed 480 cycles at a 30-cps rate.

Goniometer—A motor-driven variable capacitor gang by which the unmodulated rf signal is coupled to the variable carrier sections of the antenna. The goniometer changes polarity and varies its output sinusoidally with no change in loading. Its action resembles that of a voltage divider and polarity switch operating at a 30-cps rate.

Hunting (motor)—A process by which the voltage regulator control motor continuously seeks its correct setting, changing its direction of rotation frequently but never stopping on correct position. Caused by setting the sensitivity control too high.

Identification signal—A modulated signal that identifies the omnirange site by transmitting its assigned call letters.

Integrated alarm circuit—The circuit section of the course monitor by which malfunction alarms of any kind actuate the omnirange set shutdown and/or automatic changeover units.

Limacon—The eccentric antenna radiation pattern that results from vector addition of the reference phase pattern (circular) and the variable phase (rotating figure-of-eight) pattern.

Line wattmeter—An instrument for measuring radiofrequency power in a transmission line at the point of insertion, regardless of the direction of current flow.

Load wattmeter—An instrument for furnishing a dummy (or artificial) load during radiofrequency power measurements.

Loop resistance—A procedure for measuring continuity of long lines by using chassis or ground for a meter return, or to measure continuity of a paired telephone line by joining the two conductors at one end, making possible a measurement at one point, across the conductors at the open end of the line.

Magnetic North—The direction indicated by a magnetic compass free of other magnetic influences, which is the direction to the magnetic north pole, *not* the True (or geographic) North pole. The angular difference between True North and magnetic North (known as variation) varies with geographic location of the observer.

Minor switch—The dial-operated stepping switch which selects one of several connections or circuits in accordance with electrical pulses furnished by the dial.

Navigational facility—The omnirange set function which yields course or bearing information to aircraft.

Neutralize—A process by which self-oscillation of radiofrequency amplifiers (caused by tuning grid and plate circuits to the same frequency) is prevented. It usually involves cancellation of plate-to-grid feedback by balancing out the plate-to-grid capacitance of the tube or tubes.

Omnidirectional—In all directions.

Omnirange—The electronic system by which omnidirectional course or bearing information from a fixed reference point is furnished to aircraft.

Phase comparator—A monitor circuit which compares the phase of 30-cycle reference signal and the 30-cycle variable signal to produce a resultant polarized dc signal.

Phase selector—The monitor control which selects the proper variable carrier phase angle, referred to the reference carrier for use by the phase comparator. The selector is made adjustable to allow correction for the position of the AN/FRA–14.

Radial—Any one of a series of lines extending outward from a common center. In the case of omnirange equipment, any one of an infinite number of bearing lines projected in a horizontal plane from the antenna.

Radome—A nonmetallic cover for an antenna slot, to keep out moisture, dust, and foreign matter.

Reference carrier—The radiofrequency carrier radiated as an omnidirectional (circular) pattern that is amplitude modulated by the subcarrier which is frequency modulated at the 30-cycle rate.

Reference fail-safe alarm—Provides an alarm when the reference signal deviates from normal. Fail-safe operation is obtained by design which causes the same alarm when the monitor fails.

Reference level—The amplitude of the reference subcarrier at the monitor input.

Repetition rate—The setting of the cycle wheel to govern the rate at which the station call letters are repeated.

Reflected power percentage—The ratio, expressed as a percentage, of power applied to a load, through a transmission line, to the power reflected back into the line by the load.

Sequence timer—A motor-driven series of segmented discs and cam-actuated switches, by which switching operations can be carried on in a fixed sequence, and at desired time intervals.

Simplex line—The line for transmitting dial pulses and voice signals from the remote control unit to the omnirange site.

Sinusoidal—The variation of an alternating quantity (voltage, or current) which varies in amplitude as the sine of the angle from 0° when its instantaneous value is plotted to a time base.

Slope detector—A monitor circuit for demodulating the subcarrier (9,960 cps) signal to recover the 30-cycle reference signal for the phase comparator circuit. The circuit consists of a tuned diode rectifier which is tuned off frequency. Frequency changes result in amplitude changes to the diode.

Space modulation—The method used to provide amplitude modulation at the 30-cycle rate of the variable carrier. Consists of two rf carriers of the same frequency, one radiated omnidirectionally (reference) and the other forming a rotating limacon by vector addition of a figure-of-eight pattern. As the limacon rotates past an antenna in space, the limacon adds to and subtracts from the effective reference carrier at the antenna, thus resulting in 30-cycle amplitude variations in the antenna.

Standing-wave ratio—The ratio of current (or voltage) at a loop in a transmission line to the value at a node. The square of the voltage ratio is the standing-wave ratio in power. It is equal to the ratio of the characteristic impedance of the line to the load connected to the output end of the line.

Subcarrier—The modulation applied to the reference carrier. Consists of a 9,960 cps center frequency signal which is frequency modulated (±480 cycles) at the 30-cycle rate.

Transfer cycle—The fixed sequence of switching operations by which the C–1840/FRN–22 selects equipment No. 1 or equipment No. 2 after a signal failure.

Transit—A surveying instrument with which objects may be aligned vertically or horizontally, by means of a sighting telescope.

Variable carrier—The unmodulated radiofrequency carrier used to excite the antenna slots alternately to provide the rotating figure-of-eight radiation pattern needed to form the limacon for navigational information.

Variable fail-safe alarm—Provides an alarm when the variable signal deviates from normal. Fail-safe operation is obtained by design which causes the same alarm when the monitor fails.

Variable level—The amplitude of the 30-cycle variable signal at the monitor input.

VOR course—One of an infinite number of radials projected from the omnirange site in a horizontal plane with magnetic North as a reference.

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[AG 413.44 (1 Feb 60)]

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